

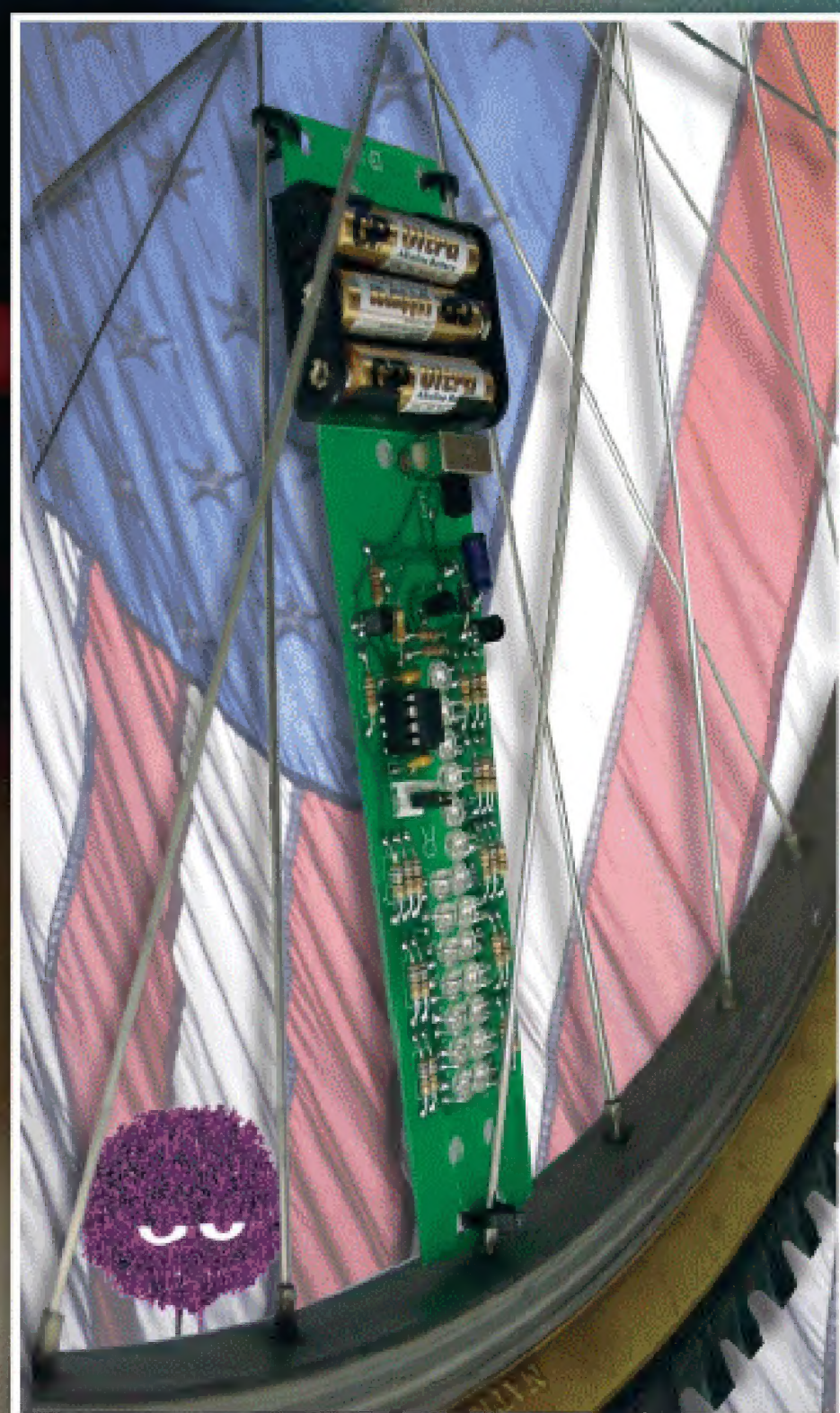
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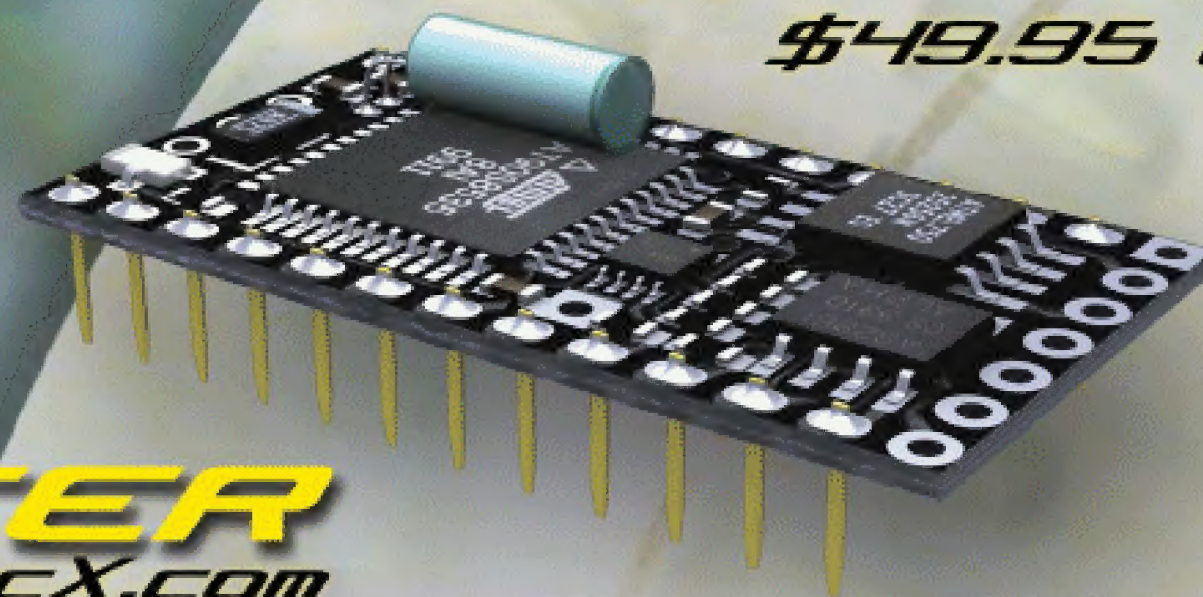
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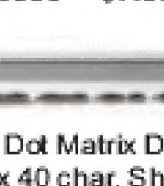
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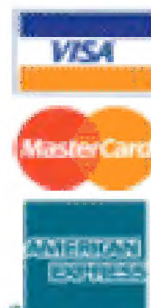


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TABLE OF CONTENTS

Vol. 26 No. 6

PROJECTS and FEATURES

COVER STORY

- 52 SPOKE SIGNALS**
LED Virtual Image Generators
for Your Bicycle
by Leon W. Schmidt
- 40 HIGH STEPPING
AUTOMATIC COIL WINDER**
An Intro to Precision Positioning
by Robert Lang
- 48 USB 16-BIT CONVERTER**
Construct a Mini USB Soundcard to
Add to a Desktop or Portable PC
by Carlos Verdonck

- 62 CONVERGENCE 2004**
Vehicle Electronics to
Digital Mobility
by Chuck Hellebuyck
- 66 EXCELLENT CIRCUITS
WITH EXCEL**
Using Spreadsheets for
Digital Circuits
by Peter Stark

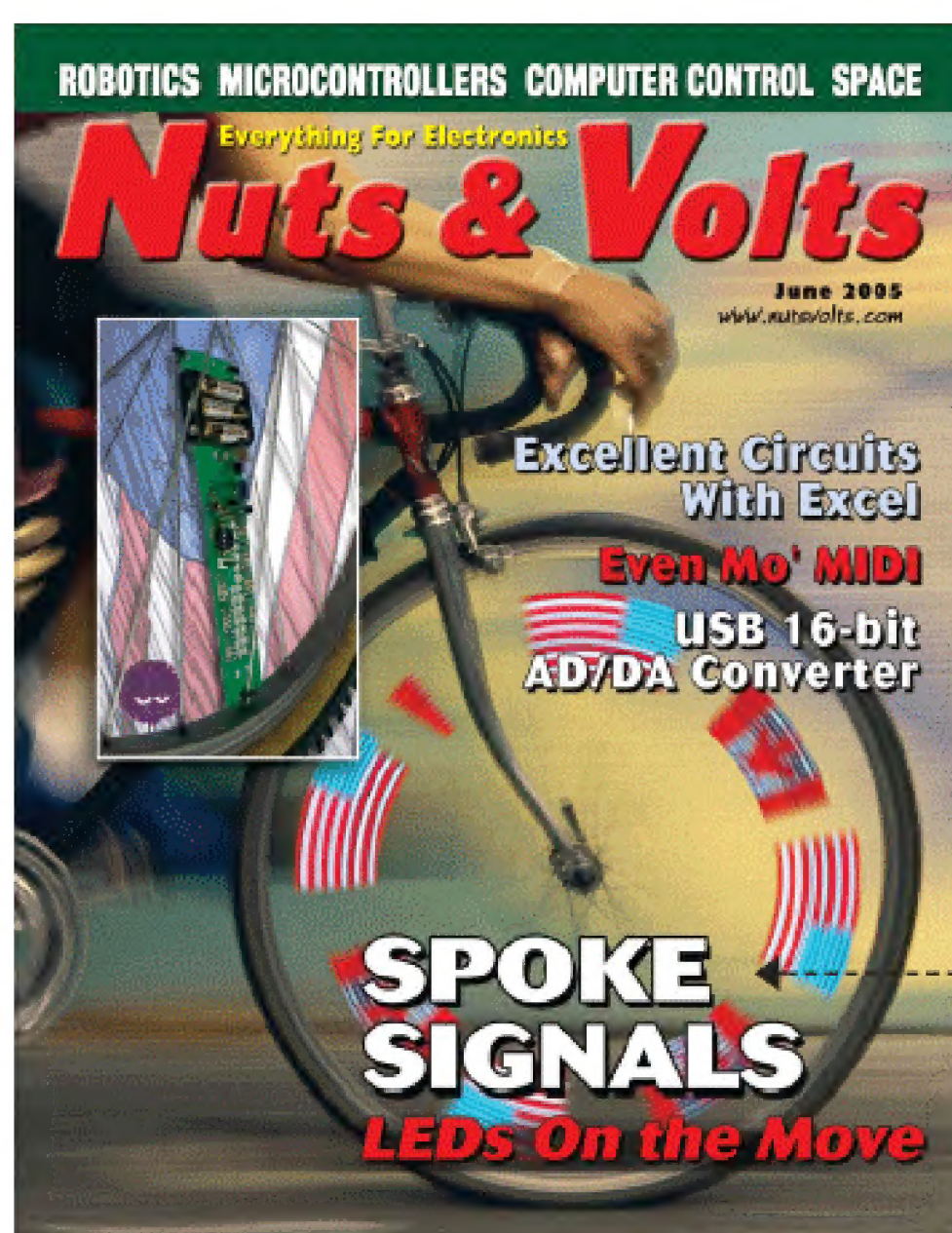
JUNE 2005

COLUMNS

- 08 STAMP APPLICATIONS**
Even Mo' MIDI
- 16 Q&A**
Soft-start Power Supplies, Line-
Controlled Battery Charger, Remote
Tablesaw/Vac Switch, plus more ...
- 22 PERSONAL ROBOTICS**
Bouncing Ideas Around for a
Ball Balancing Bot
- 26 IN THE TRENCHES**
Tips and Techniques Revisited
- 77 OPEN COMMUNICATION**
Radio Frequency Identification
- 83 TECHKNOWLEDGEY 2005**
Events, Advances, and News from the
Electronics World
- 90 THE DESIGN CYCLE**
Creating a Monster — Micro64 Style

DEPARTMENTS

- 06** Reader Feedback
32 New Products
36 NV Bookstore
72 Classifieds
74 News Bytes
76 Tetsujin 2005
82 Electro-Net
88 Electronics Showcase
101 Tech Forum
105 Advertiser's Index



p. **66**

p. **8**

p. **48**

p. **52**

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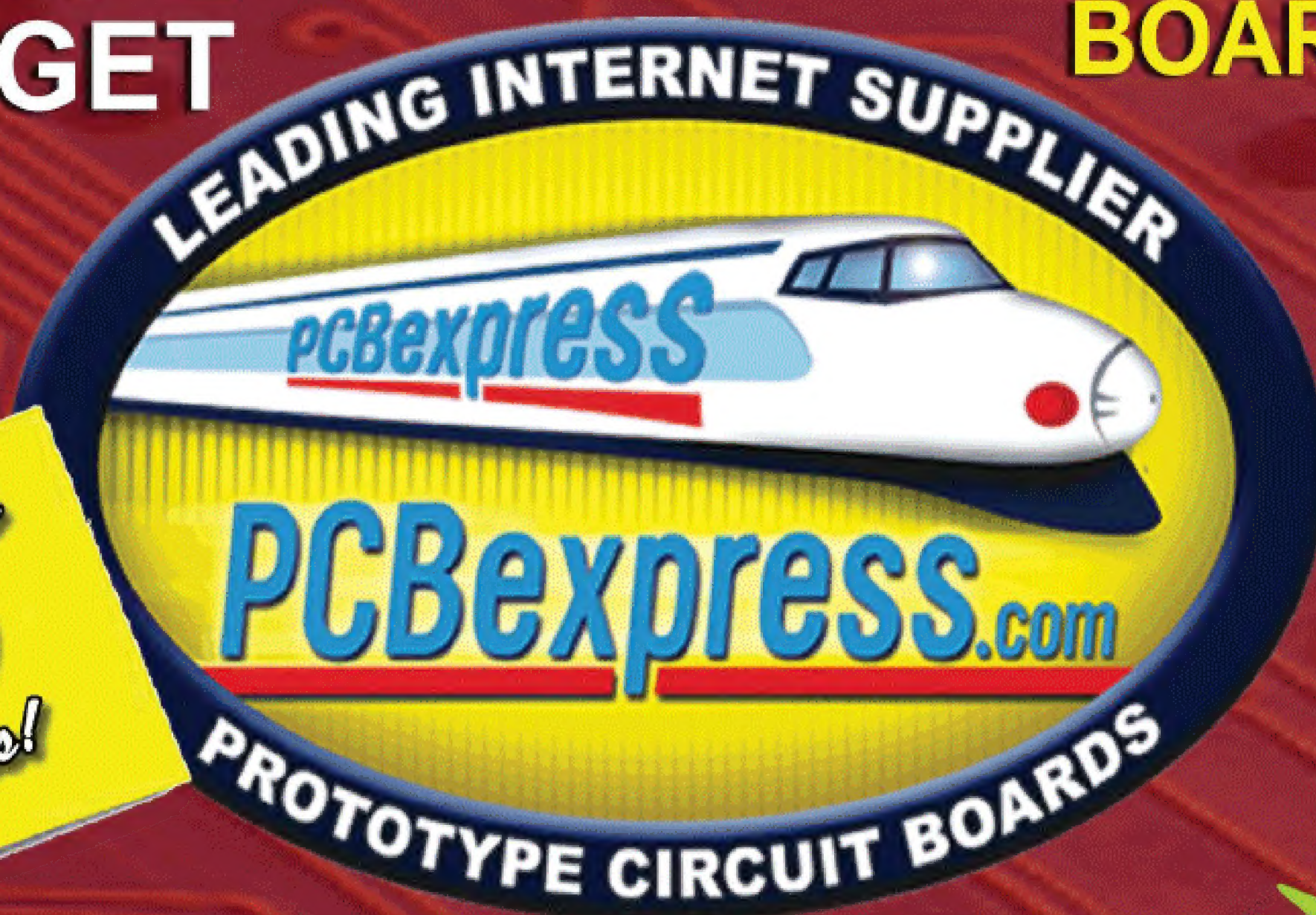
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Reader Feedback

Dear Nuts & Volts:

May I again compliment Gerard Fonte on "In The Trenches." I received my May 2005 issue of *Nuts & Volts* with "Teaching and Training" as the "In the Trenches" topic and by chance did a small class at GE Research.

One of my most important techniques is as Fonte stated, "If you understand the concepts, the details often become self-evident." This is important whether training or solving a problem, and then wanting to apply what you have just learned to different situations.

Even if someone thinks they know a subject, Fonte's articles always provide more to learn, a different perspective, and are presented in a format we want to learn and apply from.

Vaughn

Dear Nuts & Volts:

Enjoyed the article in the April issue on antennas by Louis Frenzel. It was most informative. I do have two questions, though: I intend to cut a dipole for 433 MHz. I usually just fold the ends and solder them together for a dipole. If I use 300-ohm twin lead, that's about 1/2" per end. Does that count as part of the total length? At this frequency, it matters. Also, can I use 50 or 75 ohm coax and skip the

balun adaptor? Many thanks!

Steve White

Glad you liked the antenna article, Steve. You can do the folded dipole with 300-ohm twin lead as you describe but there is no big advantage to using it. Folding the ends over to solder the two leads together does NOT count in the length calculation. However, because of the velocity of propagation in the twin lead, multiply your length calculation by 0.8 to get the correct value. And no, you cannot avoid the balun if you use the twin lead, as it is needed to match the 300 ohm impedance of this antenna to the coax.

An easier way is just to cut yourself a simple dipole with copper wire. The length is calculated with the formula $468/f$ where f is the frequency in MHz. The length will come out in feet. Then divide by 2 and cut two pieces of copper wire that length. Solder 50 or 75 ohm coax directly to the center of the two pieces of wire: center conductor to one wire and the shield to the other. This dipole will work just as good as the folded dipole and you don't need the balun. Hope that helps.

Lou Frenzel

Dear Nuts & Volts:

If the intent of the Strobe Light article in the May issue is to facilitate strobe light photography, why waste someone's time building the flash when there are many low-cost electronic flash units available? I saw several dozen used flashes in a photography store the other day, many with multiple power settings that will allow flash durations down to 1/30000 second or less.

Jerry Nicholson

Continued on Page 89



by Jay Shuman

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FOUNDER/ASSOCIATE PUBLISHER
Jack Lemieux

PUBLISHER
Larry Lemieux
publisher@nutsvolts.com

**ASSOCIATE PUBLISHER/
VP OF SALES/MARKETING**
Robin Lemieux
display@nutsvolts.com

CONTRIBUTING EDITORS
Gerard Fonte TJ Byers
Peter Best Jon Williams
Jeff Eckert Peter Stark
Louis Frenzel Leon Schmidt
Mike Keesling Robert Lang
Chuck Hellebuyck Carlos Verdonck

CIRCULATION DIRECTOR
Mary Descaro
subscribe@nutsvolts.com

SHOW COORDINATOR
Audrey Lemieux

WEB CONTENT/NV STORE
Michael Kaudze
sales@nutsvolts.com

PRODUCTION/GRAPHICS
Shannon Lemieux

STAFF
Dawn Saladino

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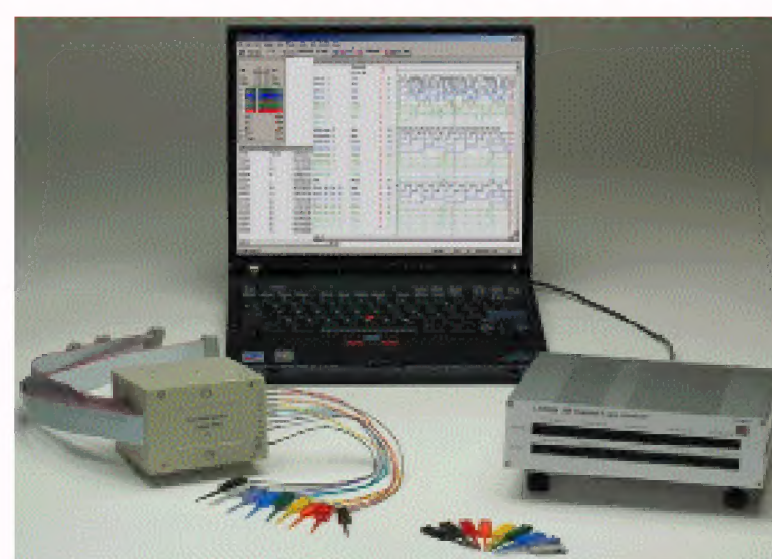
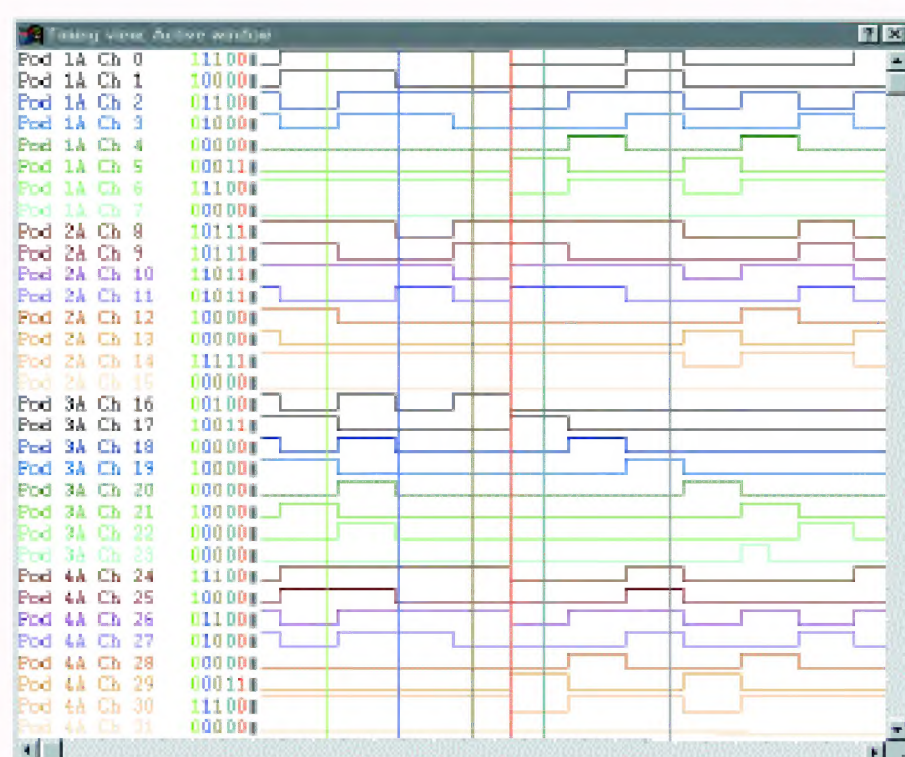


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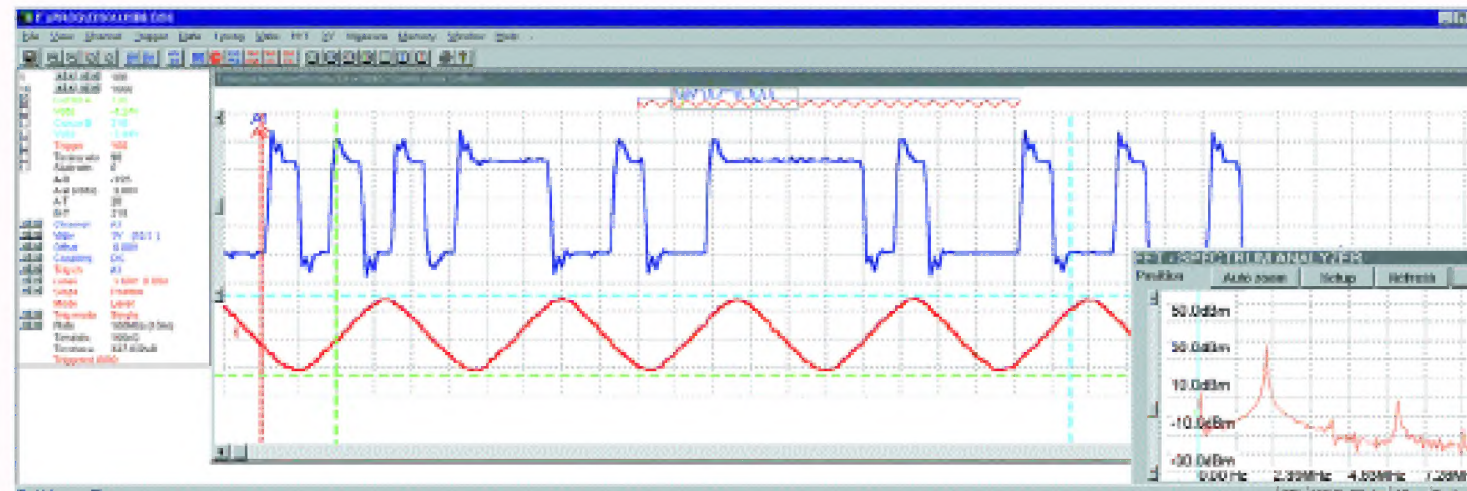
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Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Stamp Applications

Even Mo' MIDI

About two years ago, I did a couple columns on MIDI (Musical Instrument Digital Interface) using a BASIC Stamp 2 microcontroller. Our experiments at the time were limited to sending MIDI data. These articles generated a lot of interest, and the most pressing question has been, "How can I receive and process MIDI data in my project?" The fact is that it's very tough to do that effectively with a BASIC Stamp, but now that we're equipped with SX/B, we're ready to rock ... and roll ... and do anything else we choose to do with a MIDI data stream.

In the event you haven't actually heard of it yet, MIDI is a serial communications scheme developed to link instruments like synthesizers together. It's not particularly difficult; data is sent at 31.5 kBaud in small packets. The tough part for BASIC Stamp users is that the packets can vary in length; this creates a real challenge for **SERIN**. And the reality is that the processing time of bytes already captured would cause us to miss other data in the stream. What we need is a serial buffer to capture everything and allow us to process data on-the-fly.

Since there's a good chance that this project could become a product for the new Parallax EFX group, I wanted to keep the cost and parts count low — this kind-of precludes the use of a BASIC Stamp and an external UART to capture the data. What we need is a chip we can program in Basic that will buffer the MIDI data while we're doing other things. Oh, hey, we already have one: the SX micro — when we program it with the SX/B compiler.

SX/B 1.2

It's no big secret that I work for Parallax, and that I'm part of the SX/B team — still, I'm very proud that the company has provided this product at no charge, and continues

to make improvements to it. Honestly, SX/B has opened a whole new world for me personally as I just don't have the patience to program in 100% assembly. A routine here and there, no problem — the whole doggone program, no way.

Version 1.2 of the SX/B compiler adds support for the SX48 and SX52, and — what I think is best — is that it simplifies the use of code pages in the SX. You'll remember in our December and January projects that we created a "jump table" to get to subroutines located on another code page within the SX. With SX/B 1.2, all we have to do is declare our subroutines (with SUB) and the compiler handles the rest. Oh, another time saver is IF-THEN-ELSE. Yes, this makes decision-making a lot easier and saves us from having to insert our own labels to handle the IF-THEN branching. Of course, there are other improvements in the compiler, but these are the features that I think programmers will find most useful.

MIDI Controller

My colleague, John Barrowman, and I started a group called Parallax EFX to build products for the props and FX industry (movies, TV, holiday displays, etc.). As we spend more time with folks who build props, we're finding an increasing interest in MIDI control — this is especially true with those folks building Halloween displays. The idea is to use a computer-based sequencer to play audio tracks and send MIDI messages to electronic circuits that control prop actuators and effects devices. This month's project is the electronic control end of things.

Before we get to the details of the circuit and code, let's chat a little about the MIDI messages and the challenges we face. In a simple world, a MIDI device would use fixed length packet — perhaps doing something like this:

```
90 3C 64    ` note on for middle C
80 3C 00    ` note off for middle C
```

Well, we can dream, but MIDI is not so simple in application. What we'll actually see — from most instruments and sequencers — is this:

```
90 3C 64    ` note on for middle C
3C 00       ` note off for middle C
```


Huh? What happened to the status byte for the Note Off command (should have been \$80)? The truth is that it's not really used much. What happens is:

```
90 3C 64    ` note on for middle C
90 3C 00    ` note off for middle C
```

The logic here is that turning a note on with a zero velocity (initial volume) is the same as turning it off. So why didn't we see the second \$90? Running Status. You see, MIDI data isn't flying around particularly fast, so anything that can be done to reduce the number of bytes in the stream is helpful to system performance. The MIDI protocol employs a strategy called running status to do this. What this means is that the MIDI receiver is expected to keep track of the last valid status byte and use it when a data byte shows up when a new status byte is expected. In the example above, the receiver would know to use the last valid status byte (\$90) when a data byte arrives unexpectedly.

Alright, I've been a little loose with terms ... how do we know the difference between a status byte and a data byte? Luckily, the folks who created the MIDI standard made it pretty easy: status bytes are \$80 and higher; data bytes are \$7F and lower. While this helps us determine what's what,

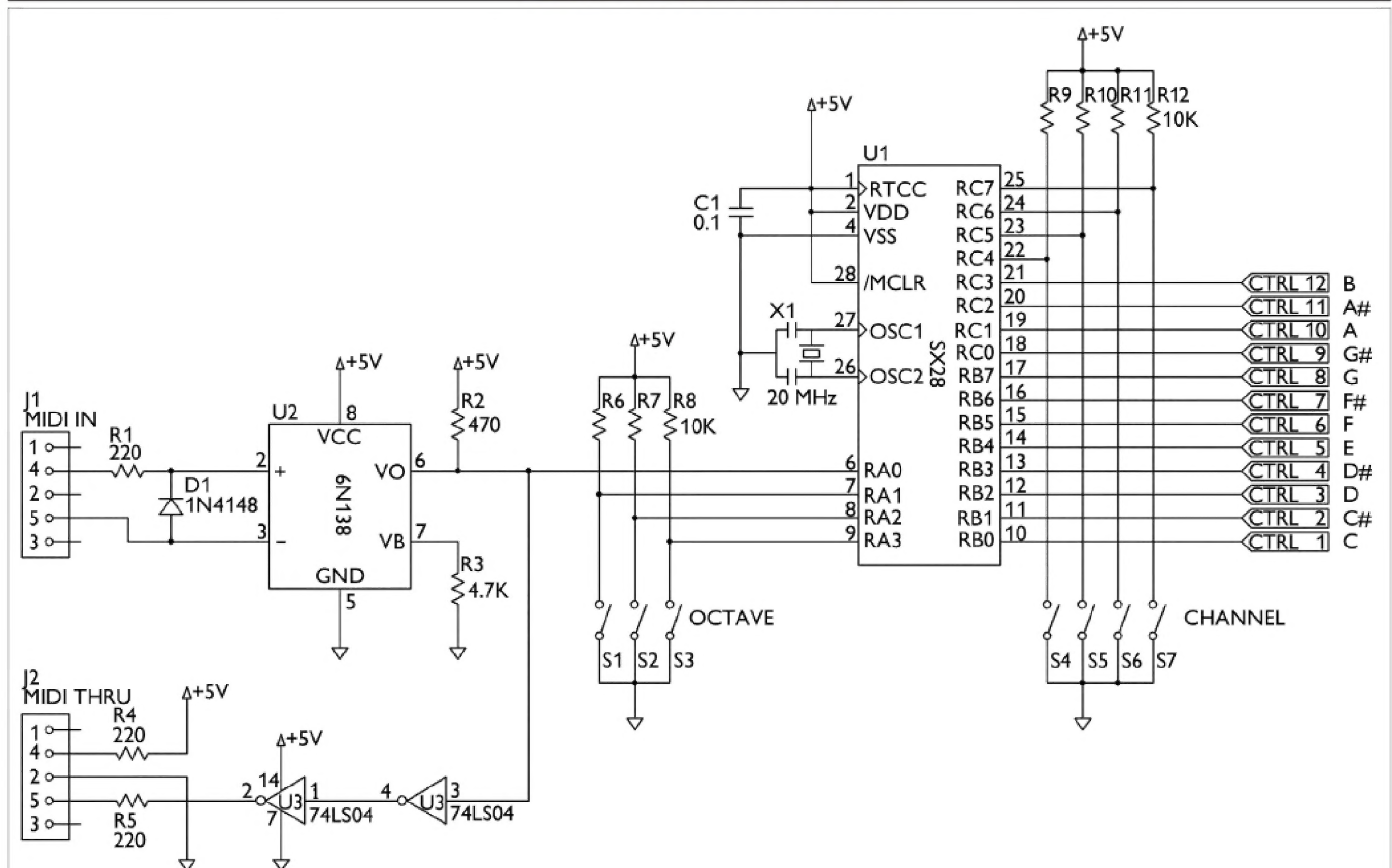
it actually creates a bit of work in some circumstances. A pitch wheel change, for example, sends \$Ex (x is the MIDI channel) followed by two bytes that represent the 14-bit pitch wheel value — but each byte only has seven bits, so the receiver has to reassemble them to get a usable value.

MIDI In — Control Out

Okay, let's jump into the project. Our goal is to "listen" to a MIDI stream and respond to Note On and Note Off messages that match our channel and octave settings. Now, there are more legal notes that what we want to deal with in a small controller, so our design will handle one: control output 1 will be assigned to C in the selected octave; control output 12 will be assigned to B in that same octave.

This choice works very nicely with the number of I/O pins available on an SX28. Have a look at Figure 1, the schematic for the project. MIDI data is actually transmitted through a current loop, and the specification says that one MIDI output will feed just one MIDI input. The 6N138 optoisolator converts the incoming current loop to a TTL level serial signal that gets fed to the SX28. It also gets routed, through two inverters, to a MIDI THRU port. This lets us insert our controller in a chain of MIDI-compatible devices.

Figure 1. MIDI Controller Schematic.



The serial data coming into RA.0 is 31.25 kBaud, N81, true (idle state is high) mode. A start bit, then, will be when the serial line goes from Vdd to Vss. Back in January, we did a project that captured serial data in an ISR (interrupt service routine) and that same code is used here. The only thing we have to change is the Interrupt period for the MIDI baud rate.

At 31.25 kBaud, each MIDI bit is 32 microseconds wide. Sticking with the idea that we should sample the serial line at least four times per bit period, we need to set up the ISR to trip every eight microseconds. This isn't very hard to do with SX/B; we simply put the number of cycles for our interrupt period after the **RETURNINT** instruction. So, what is that number?

We can calculate it like this:

$$\text{Cycles} = \text{Freq} / \text{Prescaler} * \text{Int_Period}$$

With a clock frequency of 20 MHz, a prescaler setting of 1:1, we get 160.

$$20,000,000 / 1 * 0.000008 = 160$$

What would happen if we decided to bump our clock

frequency up to 50 MHz? We'd get:

$$50,000,000 / 1 * 0.000008 = 400$$

Houston, we have a problem — the value following the **RETURNINT** must fit into a byte. What we would have to do is bump the RTCC prescaler to 1:2, and then things work out:

$$50,000,000 / 2 * 0.000008 = 200$$

This is about the only tricky aspect of dealing with the ISR serial code; we really have to keep on top of things when it comes to the numbers. If we do, we'll be rewarded because the serial code happily receives and buffers incoming data while we blissfully run our foreground code.

```
ISR_Start:
    ASM
    MOVB C, MidiIn
    TEST rxCount
    JNZ RX_Bit
    MOV W, #9
    SC
    MOV rxCount, W
    MOV rxTimer, #6

RX_Bit:
    DJNZ rxTimer, ISR_Exit
    MOV rxTimer, #4
    DEC rxCount
    SZ
    RR rxByte
    SZ
    JMP ISR_Exit

RX_Buffer:
    MOV FSR, #rxBuf
    ADD FSR, rxHead
    MOV IND, rxByte
    INC rxHead
    CLRB rxHead.4
    ENDASM

ISR_Exit:
    BANK $00
    RETURNINT 160
```

Other than the timing change for MIDI, this is, in fact, the same code we used back in January for the LED multiplexer (see that article for a description of the serial receive and buffer routine). Now that we have MIDI data collecting in a 16-byte circular buffer, we can start pulling it out and comparing it to the commands that our device will respond to (specifically Note On and Note Off).

As we move down the listing into the heart of the program, we encounter something new: subroutine declarations. This is my favorite aspect of SX/B version 1.2.

GETBYTE	SUB	1
GETCHANNEL	SUB	
GETPORT	SUB	1
SETCTRL	SUB	2

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The declaration of subroutines does two things for us: 1) It causes the compiler to create a jump table to the actual code, saving us the trouble of doing that, and 2) It causes the compiler to validate the number of parameters passed to a subroutine — this is a very big help and prevents a lot of program bugs from causing problems.

The number following the **SUB** declaration tells the compiler how many parameters — if any — are required by the subroutine. Better yet, the compiler can even check for a variable number of parameters. For example:

```
DELAYUS      SUB      1, 2
```

In the declaration for DELAYUS (not used in the MIDI program), we're telling the compiler that we must pass at least one parameter, and that we could pass two. The help file has several examples that show how to use variable parameter declarations.

Finally, when using a declared subroutine, we don't have to use the keyword **GOSUB** anymore. As you look through the project listing, you'll see lines like:

```
GETBYTE @midiStatus
```

This code calls the GETBYTE subroutine and passes the address (@) of the midiStatus variable as a parameter. As you can see, the **SUB** declaration is a really powerful feature, and for my money (yes, I know SX/B is free ...), the best improvement to the SX/B compiler.

Okay, now let's get to the actual MIDI decoding. The program starts by setting up the I/Os, enabling the ISR, and then drops into the top where we look for a status byte.

```
Main:
  IF hasStatus = 0 THEN
    GETBYTE @midiStatus
    IF midiStatus.7 = 0 THEN Main

Check_Sys:
  IF midiStatus >= $F0 THEN Sys_Cmd
  runStatus = midiStatus
ENDIF
```

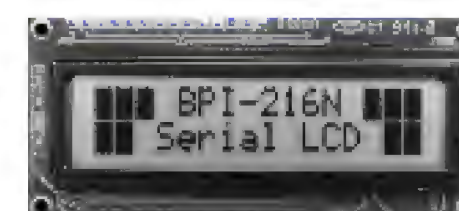
In the beginning we don't have a status byte saved, so the program will, in fact, call GETBYTE and wait for a status byte to arrive. Since status bytes are \$80 and higher, all we have to do is look at bit 7 (aliased as hasStatus) to tell if the byte received is status or not. If not, we try again.

There's a special case when the status byte is \$F0 and higher — these bytes are system commands and need to be handled separately. When we get a normal ("voice") status byte (\$80 - \$EF), we will save that in our running status variable. All status bytes require at least one data byte, so that's what we collect next.

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```
Get_DB1:
  midiStatus = runStatus
  GETBYTE @midiDB1
  IF midiDB1.7 = 1 THEN
    midiStatus = midiDB1
    GOTO Check_Sys
  ENDIF
```

You may be wondering why we need to copy the running status byte back to our midiStatus variable. Well, we'll ultimately end up here again, and if the last status byte that came in was a system byte, we need to refresh the running status byte for the incoming data. If, for some reason, we get a status byte at this point, it gets moved into the midiStatus variable and we jump to Check_Sys to handle a system byte that might have shown up. If it isn't, the process continues as before with the new status byte.

Let's say that things went well and the status byte received was \$90 (Note On, channel 1) and the first data byte was \$3C (middle C). The next thing we have to do is look at the status byte and jump to a handler for it.

```
Do_Command:
  temp1 = midiStatus & $F0
  IF temp1 = $80 THEN Note_Off
  IF temp1 = $90 THEN Note_On
  IF temp1 = $A0 THEN Aftertouch
  IF temp1 = $B0 THEN Controller
  IF temp1 = $C0 THEN Pgm_Change
  IF temp1 = $D0 THEN Chan_Pressure
  IF temp1 = $E0 THEN Pitch_Wheel
  GOTO Main
```

The first line of this routine masks out the channel data (low nibble of status byte), then does a comparison of valid commands and jumps to the proper routine. Why jump to a routine if the channel doesn't match? Well, the

status and data bytes are in the buffer anyway, and they have to be pulled out. (I suppose we could come up with a clever routine to manipulate the buffer head pointer, but that could lead to more complications than it's worth, especially since we need to check for system commands.)

In our case, we're going to jump to Note_On:

```
Note_On:
  GETBYTE @midiDB2
  IF midiDB2.7 = 1 THEN
    midiStatus = midiDB1
    GOTO Check_Sys
  ENDIF
  GETCHANNEL
  temp1 = midiStatus & $0F
  IF temp1 = channel THEN
    GETPORT @midiDB1
    IF midiDB1 < 12 THEN
      IF midiDB2 > 0 THEN
        SETCTRL midiDB1, 1
      ELSE
        SETCTRL midiDB1, 0
      ENDIF
    ENDIF
  ENDIF
  GOTO Main
```

Again, we'll call GETBYTE to get the second byte for the Note On command; this byte will hold the "velocity" (initial volume) for the note currently being held in midiDB1. And, again, we'll make sure that we didn't get a status byte when it's not expected. If we do, it's handled by moving the new status byte into midiStatus and jumping back to Check_Sys for appropriate processing. That will usually not be the case, however, what we'll end up with is a value between zero (off) and 127 (max volume).

With the entire packet removed from the buffer, we can compare the channel information in the status byte

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with the channel setting of our controller.

```
GETCHANNEL:
channel = ~CtrlHi
SWAP channel
channel = channel & $0F
RETURN
```

As you can see, checking the channel setting of the controller is pretty easy: we read the channel switch settings and invert them since we're using active-low inputs. As the channel data is in the upper nibble, we can use **SWAP** to move it to the lower nibble. This is a new command in SX/B and does exactly the same thing as its assembly namesake. It's also much quicker than using a shift instruction to move the bits from one nibble to the other.

Finally, we mask out the unused bits (high nibble of channel) and return to the program. In case you're wondering why this isn't done at the beginning of the program, the reason is it lets us change the channel setting of the controller on-the-fly. This can be very useful when we're attempting to integrate it into a MIDI system.

Now that we have the channel number from the controller, we can grab the channel data from the status byte and compare them. Let's assume a match. The next thing

we have to check for is a match for our range of outputs. Remember, there are 128 possible note values but we've only got 12 outputs. What we've done is divided the possible outputs into octaves — just like on a piano keyboard. The GETPORT subroutine does two things: it checks to see if the note value in the packet matches our setting, and it converts that value to between zero and 11, or to \$FF (not valid for us) for later use.

```
GETPORT:
temp1 = __PARAM1
temp2 = __RAM(temp1)

baseNote = ~Octave
baseNote = baseNote >> 1
baseNote = baseNote & 7
baseNote = baseNote + Transpose
baseNote = baseNote * 12
IF temp2 < baseNote THEN
temp2 = $FF
ELSE
temp2 = temp2 - baseNote
IF temp2 > 11 THEN
temp2 = $FF
ENDIF
ENDIF
__RAM(temp1) = temp2
RETURN
```

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This subroutine expects an address to be passed to it, so the second line takes care of reading the value from that address. After that, the Octave switches are read and the base note value for the controller is calculated. One thing that may require a little extra explanation is the Transpose constant. I have two keyboards, and the lowest C on both of them was actually in octave three. By setting Transpose to 3, I was able to make the lowest key on my keyboards correspond to octave zero on the controller.

Now we can compare the note sent with our own range. When it's in range, a simple subtraction will reduce the value to between zero and 11 — this corresponds to our output ports. If the note value is not in range, we'll reset it to \$FF; this serves as a flag to the program that the note is of no use to us.

Let's continue assuming that the controller was set such that pressing Middle C on a keyboard would cause the note value to be found valid, hence set to zero. The last thing we need to do is check the velocity (initial volume) value. Remember, most MIDI devices use the Note On command with a velocity of zero to turn a note off. After a simple comparison, we can call the SETCTRL subroutine with the second parameter as 1 for on, 0 for off.

```
SETCTRL:
    temp1 = __PARAM1
    temp2 = __PARAM2

    IF temp1 < 8 THEN
        IF temp2.0 = 1 THEN
            temp2 = 1 << temp1
            CtrlLo = CtrlLo | temp2
        ELSE
            temp2 = 1 << temp1
            temp2 = ~temp2
            CtrlLo = CtrlLo & temp2
        ENDIF
    ELSE
        IF temp2.0 = 1 THEN
            temp1.3 = 0
            temp2 = 1 << temp1
            CtrlHi = CtrlHi | temp2
        ELSE
            temp1.3 = 0
            temp2 = 1 << temp1
            temp2 = ~temp2
            CtrlHi = CtrlHi & temp2
        ENDIF
    ENDIF
    RETURN
```

One of the nice things the BASIC Stamp does for us is hide details about controlling I/O pins. The fact of the matter is that the I/O ports on the PIC and SX micros used to make BASIC Stamps only eight bits wide, but the design of PBASIC lets us treat the two ports as one 16-bit entity.

That's what we're doing with SETCTRL — we're treating two ports (RB and RC) as one big group. The

first thing we have to do is figure out which of the two ports is going to be affected, RB or RC. If the control port is less than eight, it's RB, otherwise it's RC. Then we check to see if the port is going to be turned on or off.

Let's stick with our Note On. In that case, we will create a bit mask for the proper pin using the shift left operator, then add (with OR) that mask to the current state of the outputs. Turning a port off requires one additional step: we have to invert the mask (putting a zero into the affected control port bit), then use AND to clear it while maintaining the current state of the other pins.

Whew ... that was a bit of work, but what we have at the moment is an output on. If we connect to an LED, we'll see it lit. Now, let's release the key. Again, what we'll probably get is only two bytes:

```
3C 00
```

At Main, we see that the byte is not a new status byte (bit 7 is clear), so we reload the running status (currently \$90), jump to Get_DB1 where we grab the \$3C note value (in midiDB1), then ultimately go back to Note_On where we get \$00 into midiDB2. Since the velocity value is zero, we'll call SETCTRL with 0 as the second parameter and the control port will be turned off.

Okay, time to take a breath.

This is one of those programs where the explanation is far more complicated than the process. That said, the process is not to be taken for granted and even after having code working for over a week now, I find myself making small improvements to it.

If you find yourself overwhelmed, but are interested in building a MIDI-compatible controller, don't fret — go do a Google search on MIDI and you'll find all kinds of useful information on the protocol and lots of projects people have done with small microcontrollers. After reading some of the protocol explanations, come back to the program listing and have a look. After a couple reads, it will start to make sense; it did for me, anyway. When I went into this project I expected it to be a little less — that was a silly assumption on my part. All's well now, though, and we have a base for all kinds of MIDI projects.

Have fun, do neat stuff with your MIDI controller and, as always, Happy Stamping! — SX/B style ... **NV**

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Electronics Q&A

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, comments and suggestions.

You can reach me at:
TJBYSERS@aol.com

What's Up:

This month, it's about power. Soft-start power supplies, line-controlled battery charger, and a remote tablesaw/vac switch.

A reader has a power voltage/continuity tester, and two readers add to the out-of-range cell phone solution.

Taming the Twitch

Q I have made several BASIC Stamp projects (using a BS2 or BS2P40) controlling one or more servos. In many instances, the servo will “jerk” when I turn on the power supplies. The servo will operate normally after that to its designated end of the program, at which time the servo(s) has returned to its starting position and power is shut off. Upon applying power again, the servo will “jerk” again. For some projects, the “jerk” cannot be tolerated. Is the problem inherent in the servo or is my Stamp program at fault?

— Ropp Triplett

A The problem is in the power supply, which is causing the servos to hunt until the Stamp outputs have settled down. What you want to do is gradually apply the power, as would be the case with a soft-start power supply shown in Figure 1. I understand that you have a variable 2.5K pot that you use to adjust the output of your home-brew Stamp power supply to 7.5 volts. With the simple addition of a transistor and 25 uF charging cap, you eliminate the big bang effect when power is applied.

What happens is that the 2N3906 transistor shorts out R1 on power-up, which limits the output voltage to 1.2 volts. As the 25 uF capacitor charges,

the resistance across the transistor gradually increases. When the cap is fully charged, the output voltage is dictated exclusively by the R1/240 ratio. The 1N4001 diode guarantees the 25 uF cap will fully discharge when power is turned off. This circuit can be used with any adjustable linear regulator, like the LM350, LM1084, etc.

Reader responds back: *Your Soft Start Regulator works beautifully. I haven't discovered any twitching yet on power up.* — RT

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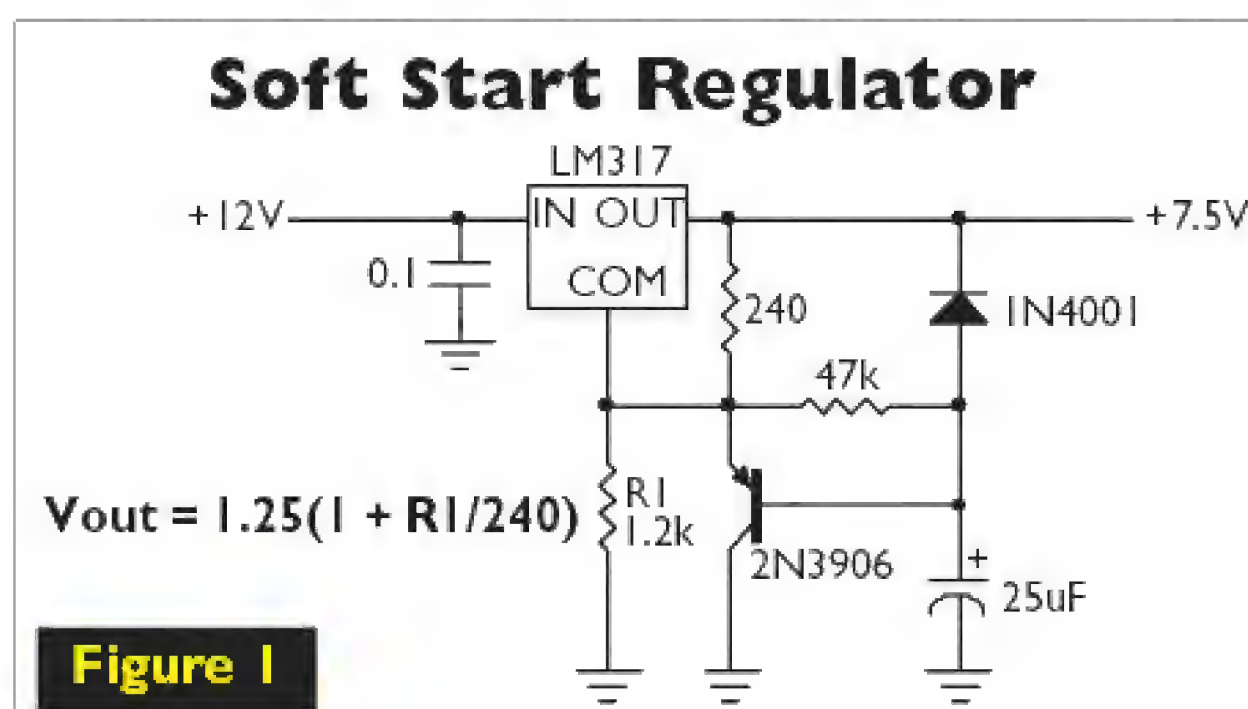
Q I need a circuit to switch on power to a 15-amp, 110-volt battery charger when the battery voltage drops to 10.5 volts — and to switch it off when the voltage rises to 11.5 volts.

— Luke Hagner

A I like the idea that you're switching the primary side of the charger instead of the output. Not only is it safer to cut the line power — less chance of fire — it also saves energy that would otherwise be dissipated in the transformer and rectifier when it's idling. Of course, you'll need to add a blocking diode in series with the charger to keep the battery from discharging through the charger.

For this design, I used a MOC3020 optoisolator driving a triac switch (Figure 2). Rather than using two comparators to switch the AC input to the charger, I'm using an LMC662 op-amp as a comparator.

To pull this off, a considerable amount of



hysteresis is needed. Hysteresis is the difference between the input signal voltage levels at which a comparator turns off and turns on. A small amount of hysteresis can be useful in a comparator circuit because it reduces the circuit's sensitivity to noise, and eliminates "chatter."

A large amount of hysteresis can create a Schmitt trigger or precision voltage-sensitive switch like the one I have provided here. There is an inverse relationship between hysteresis and the value of the feedback resistor (R1). The lower the resistance of R1, the greater the hysteresis voltage — a ratio that can be expressed by the equation: $\text{Hysteresis} = V_{cc}(R2/R1)$. The equation applies only to comparators or op-amps that have rail-to-rail outputs. For a standard op-amp like a 741, the voltage (V_{cc}) equals $V_{OH} - V_{OL}$ (voltage out high minus voltage out low).

R/C Landing Lights

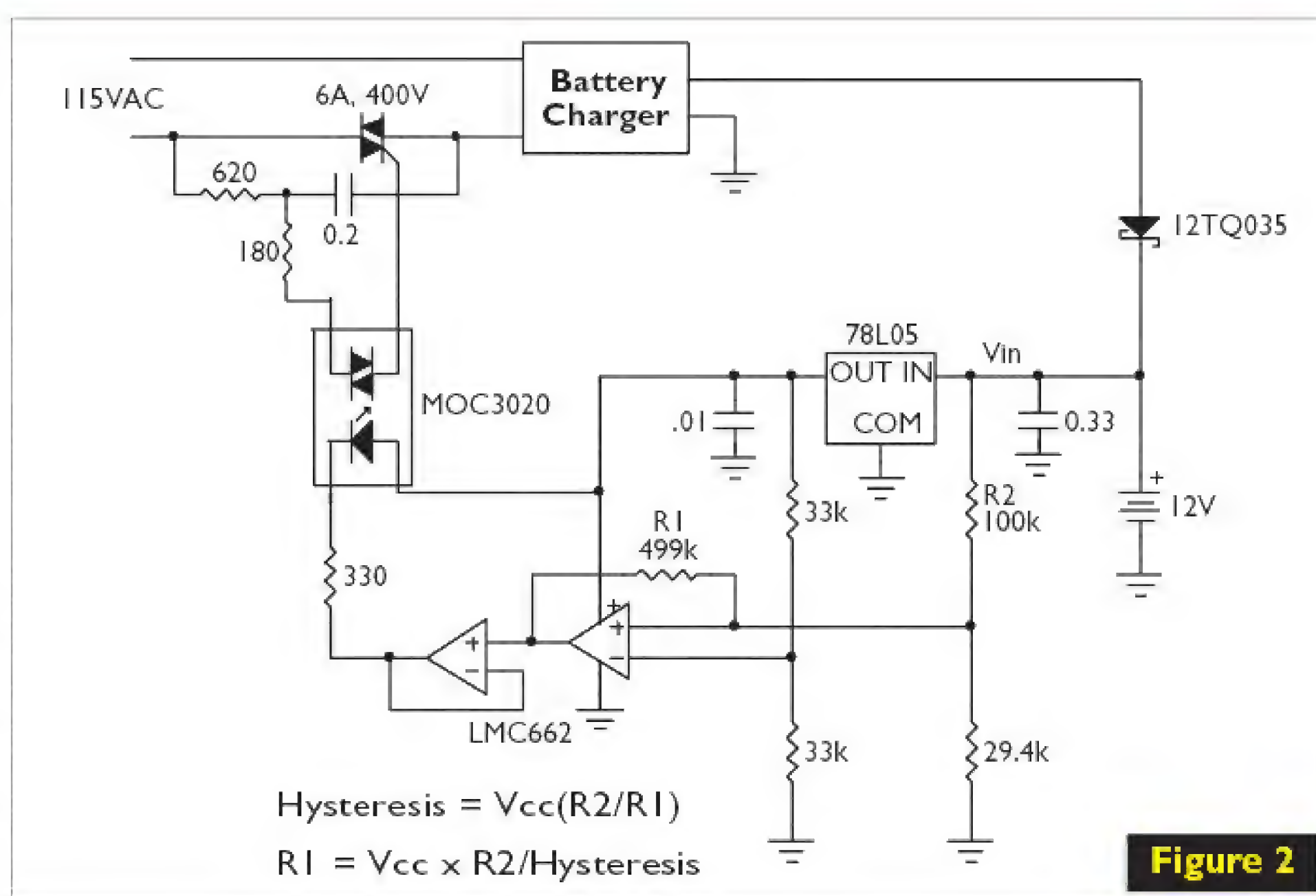
Q. I would like to replace a servo in my R/C aircraft with a simple switch for operating other functions, like turning on and off lights, in my case. The lights themselves will be powered by a separate battery, but the switch circuit would be powered by the aircraft receiver 4.8-volt battery, so current draw by the circuit is a major concern.

— Ken

A. There are several designs out there — including discrete logic and microcontrollers — that are designed to do just this. Most are application specific, like the RCE200 from www.teamdelta.com that are designed for high-current robotics motors. Yours, too, is application specific in that weight and power are paramount to current capacity. With that said, here is my favorite circuit — Figure 3. The original design was by Tony van Roon. I just changed it slightly to match your needs.

Like all R/C switches, the circuit measures the pulse width of the servo pulse width to decode your intent.

JUNE 2005



When off, the servo outputs a 1 mS pulse at a rate of about 50 Hz. When full on, the pulse width is 2 mS. Pulse widths between 1 mS and 2 mS represent 0% to 100%. This circuit uses dual D flip-flops, the first configured as a one-shot monostable multivibrator with an output of about 1.5 mS.

Here's how it works. The right flip-flop is used as a comparator. When the pulse is less than 1.5 mS wide, the D input is low before the multivibrator

triggers the flip-flop's clock — which results in a low output. When the pulse is wider than 1.5 mS, the D input is high when the clock is pulsed, causing the output to go high. The 2N2222 transistor amplifies the output and closes a reed relay when the pulse is longer than 1.5 mS.

If you want the relay to open instead, connect the 1K resistor to the \bar{Q} output. To calibrate the switch, simply toggle between full on and off

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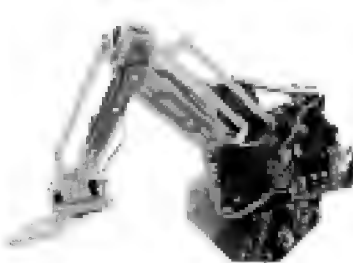


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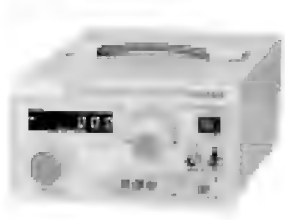
HP-9060 (60MHz) \$15
HP-9100 (100 MHz) \$20
HP-2100 (100 MHz) \$20
HP-9258 (250MHz) \$39

Audio Generators



10Hz~1MHz, sine / square
AG-2601A \$125 analog display
AG-2603AD \$225 digital display
with built-in 150MHz freq. counter

Signal Generators



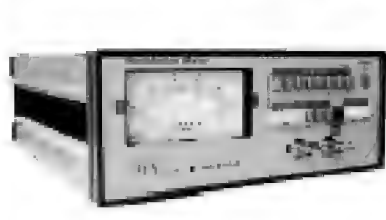
(100k~150M Hz in 6 ranges
RF output: 100m Vrms)
SG-4160B \$125 (analog display)
SG-4162AD \$224.95 w/built-in
150MHz freq. counter (digital display)

Breadboards & Jumper Wires



BB-27101 (740 contact pts) \$3.75
BB-27102 (840 contact pts) \$4.45
BB-271060 (2420 contact pts) \$17.25
Jumper Wires 140 pcs **\$3.75**
Jumper Wires 350 pcs **\$8.25**

Modulation Meter



MM-476020 \$1,595
RF input Freq. Range:
1.5MHz ~ 2GHz
FM Deviation Range:
1.5kHz ~ 100kHz in 8 ranges

AM Depth Range: 5% ~ 100% in 6 ranges

Output Signals: IN, AF, DC

AF Filter: Band Pass in 3 ranges

50Hz ~ 30kHz ; 50Hz ~ 15kHz; 300Hz ~ 3kHz

Soldering Stations



SS-31998 (15~60W) \$27
SS-31976 (50 W) \$37.50
SS-31010 (48W) \$46
SDS-31916 (solder/desoldering) \$255
* replacement tips in stock

IC Testers & EPROM Programmers



DIC-17001 (Digital IC Tester) \$179.95
LIC-17002 (Linear IC Tester) \$579.95
EDP-17003 (EPROM Prog.) \$249.95
ERE-17121A (EPROM Eraser) \$74.95
UDP-17010 (ROM Prog.) \$575.00

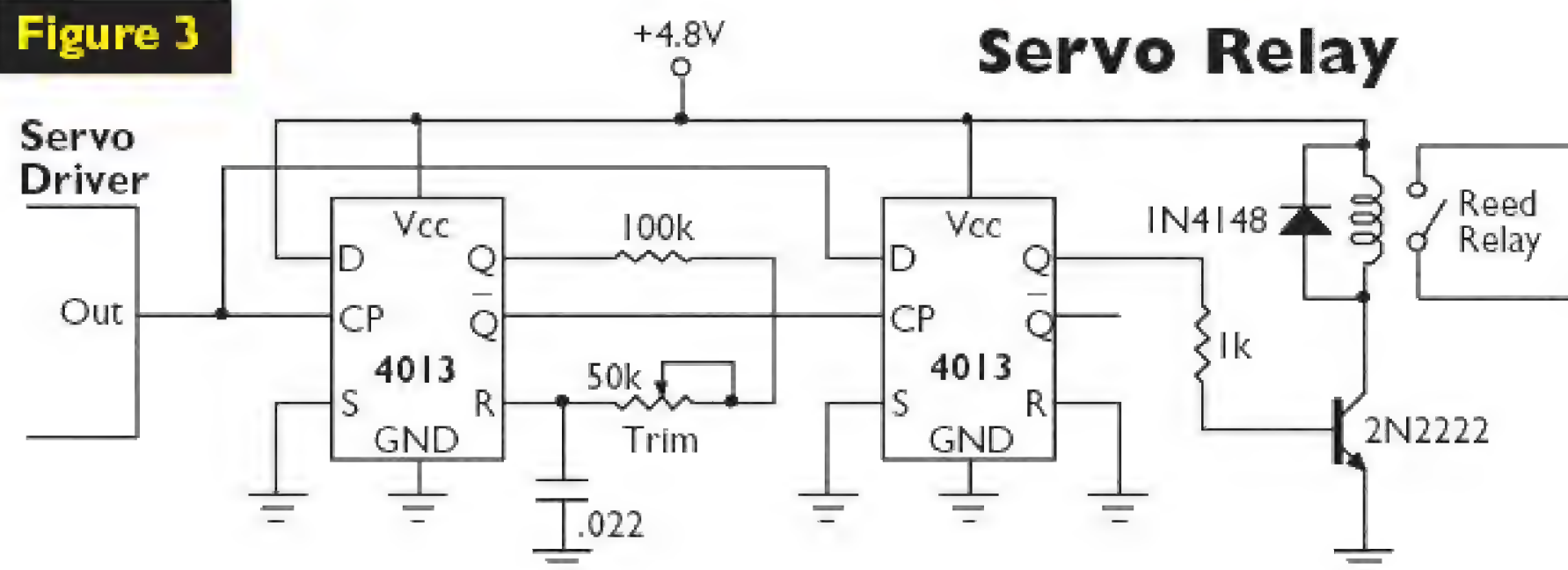
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Q&A

Figure 3



while adjusting the Trim control for proper operation.

Testing Power Transformers

Q Could you please provide a small schematic that shows me how to test the transformer of an aging car battery charger?

— **Leo Van Der Vaart**
Ontario, Canada

A There are three steps to testing any kind of power transformer — and all three can be performed using nothing more than a volt/ohm meter and a tiny wall-wart (Figure 4). Before you begin, disconnect the transformer from the circuit.

Step 1. With an ohmmeter, test the continuity of the primary and secondary windings. If the transformer has more than one secondary winding or has a center tap, check each one for continuity to all terminals. Typically, you will get a measurement of 10 ohms or less. If one of the windings measures more than 100 ohms, be very suspicious. It could

indicate an open winding.

Step 2. With an ohmmeter, measure the resistance between the primary and secondary windings. Set the ohmmeter to its highest range. If the measurement is less than 1 megohm, you probably have leakage that can compromise the safety of the transformer — as in, it could present a possible shock hazard.

Step 3. If the transformer passes the first two tests, apply a voltage of 9 VAC to the SECONDARY of the transformer. I suggest a small wall-wart adapter with a current rating of 500 mA or less. The voltage on the PRIMARY winding should measure about 90 VAC, depending on the turns ratio. If not, suspect a shorted winding. If there are multiple primary or secondary windings, measure the voltage across them, too.

I Saw That

Q Would you provide a circuit to start a 120-volt, 11.8-amp Shop Vac when the magnetic switch on a bench saw (240V, 3HP) is engaged?

— **Bob Gotts**
The Forgetful Woodworker

A Sure, find it in Figure 5. For safety's sake, a MOC3020 optoisolator separates the saw motor power from the Shop Vac power. The MOC3020's LED is powered from one leg of the 220-volt line (110 volts) through a series of voltage-dropping resistors and a zener diode. The zener is included to prevent transients on the AC line (common in a shop environment) from falsely triggering the Shop Vac.

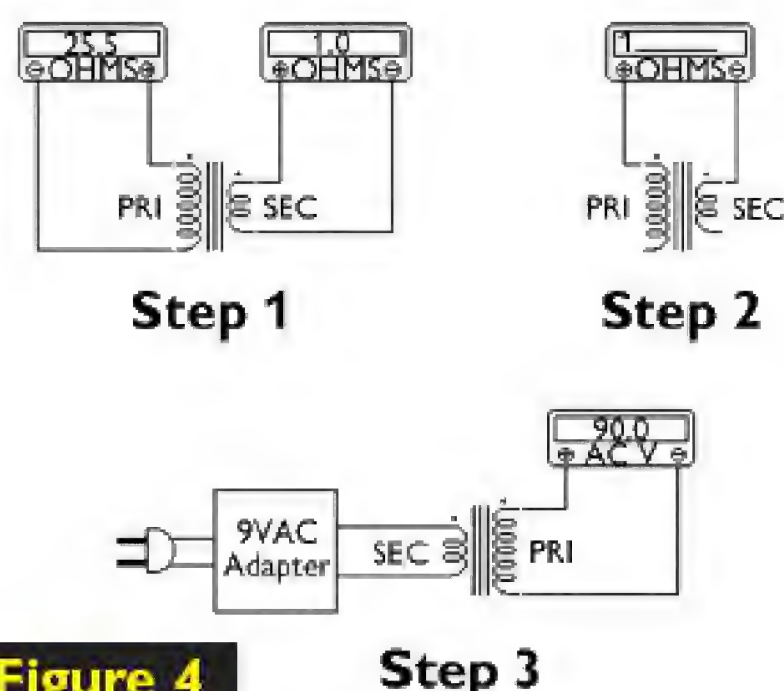


Figure 4

The circuit needs access to the bench saw motor voltage after the magnetic switch, which is easily obtained by removing the wiring cover on the motor. In fact, the unit is small enough that it can be permanently nestled inside the cover. At the receiver end, you will need to splice into the wires coming from the Vac's on/off switch. The twisted pair that connects the transmitter to the receiver should be shielded — the kind that they use for telephone burial cable.

MAILBAG

Dear TJ,

I have assembled the "Ding-Dong" doorbell chime published in the January 2005 issue. Unfortunately it did not work, and by analyzing the diagram, I note the following.

First of all, the sound can never be pleasant due to the fact that the 555 generates rectangular waves instead of sine waves. The second detail is that the 555 output is shorting the 470- μ F cap (C2) when it goes low. I kindly ask you to publish another "Ding-Dong"

with better characteristics and, if possible, with easy-to-find parts.

— Gert Wallerstein
Recife, Brazil

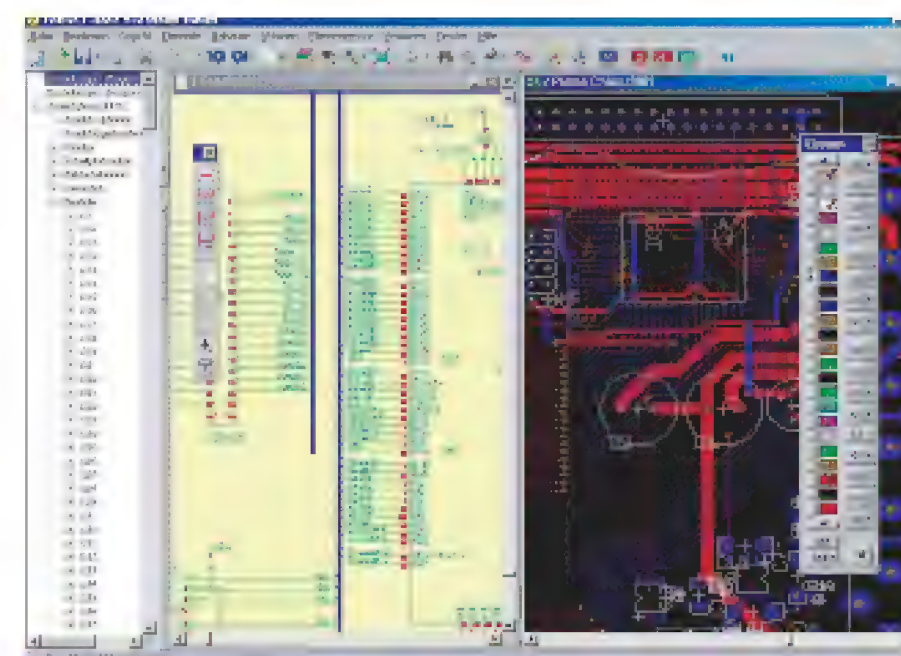
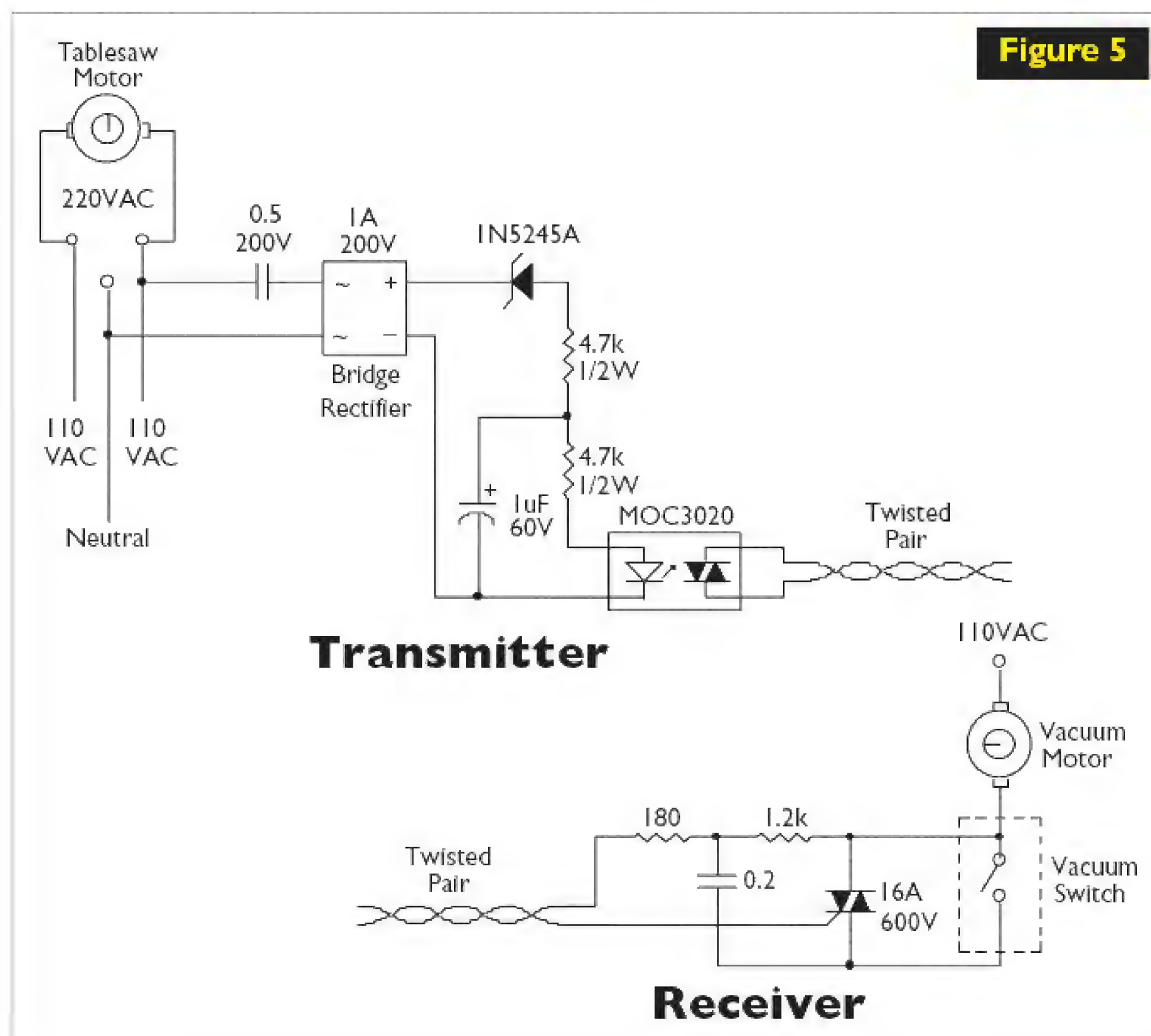
Response: I test (or simulate) nearly all my circuits before I publish them and this one is no exception. Unfortunately, I start work by scribbling on a napkin, which I take to the breadboard. In the process of moving the diagram from paper to screen, a critical diode (D1) escaped my attention. Figure 6 shows the corrected schematic. And yes, I agree a square wave doesn't have the pleasant ring of a sine wave. I'm working on a new design now. Stay tuned.

— TJ Byers, Q & A Editor

Dear TJ,

I have a comment and a solution for some of your readers that are inquiring about low signal in their home cell phones.

First: Using two antennas with a



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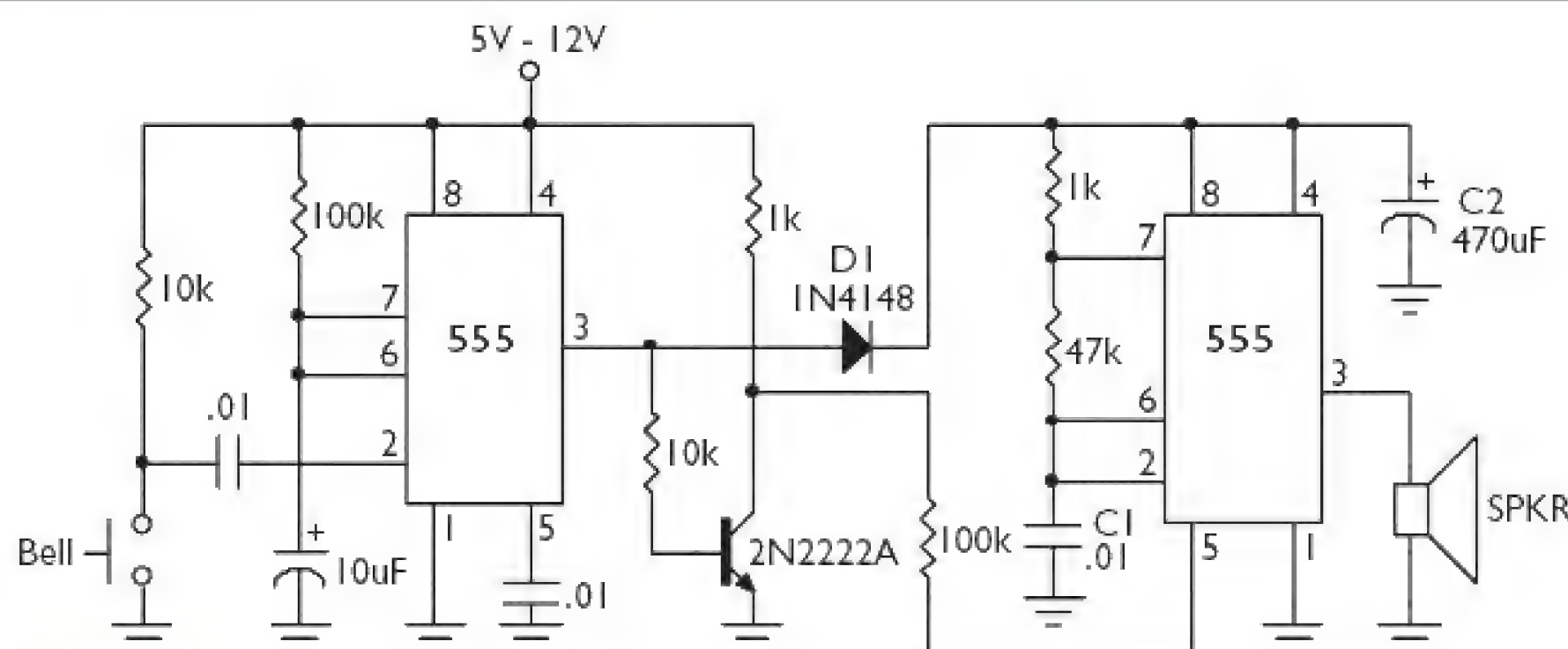


Figure 6

Doorbell Chime

short piece of coax between them to strengthen the signal in a building (passive repeater) will not work unless the signal outside the house is really strong — not normally the case. The solution is to use a BDA (Bi Directional Amplifier). There are two types available from Antenna Specialist (www.antenna.com/cellular_cat/cellpg32.html) that I

have used and found to work pretty well in most applications.

Second: I would NOT use the RG-58 coax cables that are shipped with the kits. I'd use half-inch LDF coax instead to quadruple the signal strength.

— Jack Burns
Sr. RF Engineer
Chillicothe, OH

Dear TJ,

I thought your answer (March 2005) to Walt Brackmann about finding a cell phone antenna for indoor use was very interesting. In fact, I am planning on building one myself. If that doesn't quite satisfy his need, I would suggest he go to any truck stop, and buy a trucker's cell phone antenna that mounts on the cab's mirror. I have seen high gain(>12db) and ground plane style of truck mobile antennas that looked to me like they could be quite easily adapted to home, outdoor mounting use.

The C.Crane (www.ccrane.com) catalog lists one such antenna. When you specify the model phone, they even throw in the external antenna adapter! He just would not be able to freely walk around and talk inside the house because of the coax cable/antenna adapter.

C.Crane also lists a mobile magnetic antenna. I have personally used this inside the house, plugged into one of my cell phones, and I couldn't believe the increased signal levels! A system like this works well, and you can even walk around the house and talk with it (as long as you carry the antenna around with you!).

— Stu Tell

Cool Websites!

Three technologies used to record and store data on removable media: magnetic, optical, and solid-state. Which is best?

<http://nl.internet.com/ct.html?rtr=on&s=1,1ekv,1,7dtj,ikku,3qmh,cu1s>

Do you think you've done dumb things

to your PC? Wait until you get a look at these images.

http://snipurl.com/DumbPC_tricks

Answer pithy questions in the "Don'tGrossOutTheWorld" Flash game.

<http://snipurl.com/foodfight2>

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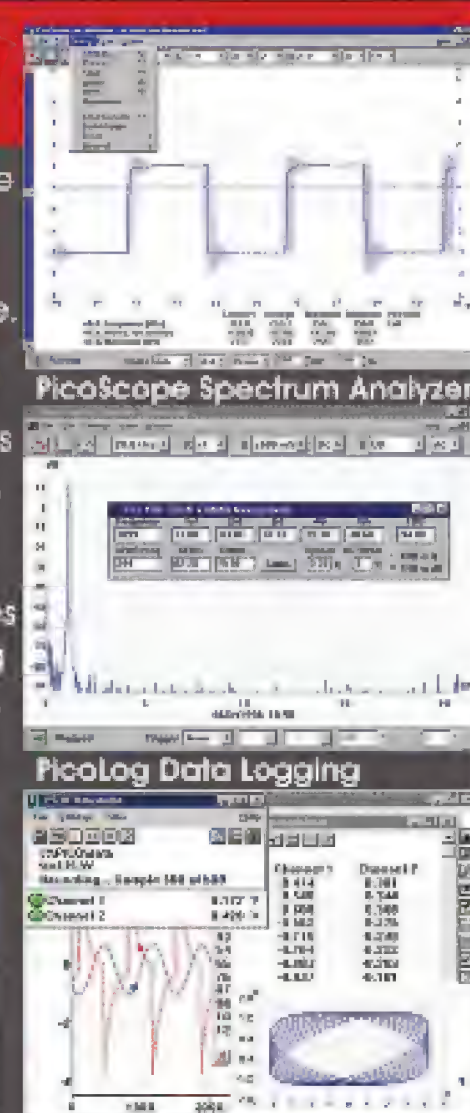
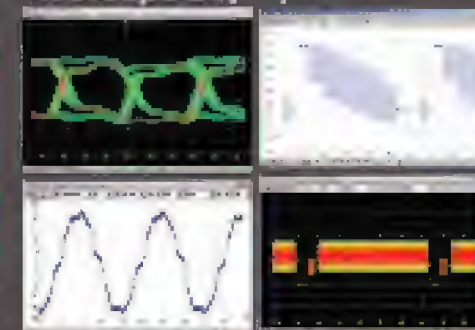
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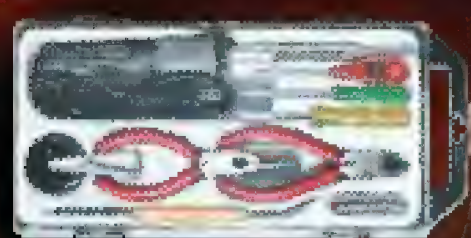
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Understanding, Designing, and Constructing Robots and Robotic Systems

Personal Robotics

Bouncing Ideas Around for a Ball Balancing Robot

When the desire to build something really cool and the need to make room on the shelves converge, there can only be one answer ... eBay.

It hurt to let my little friends go, but in all fairness to them, they were just gathering dust anyhow. It's just that I really wanted to do something on a grand scale – not big – but grand.

The bug has been stirring in me for quite some time. I rued over doing a giant, 22' long robotic centipede with 36 cheap electric drills. I considered doing a seven-joint-per-leg biped, and even a 10-legged scorpion. After several days of incessant

moaning at work, my co-workers suggested that I build a one-legged hopper. Now, I have done some stupid things on a dare, and although I am mad, I most certainly am not crazy.

I did, however, derive some inspiration from my robot building comrades in arms, and decided to build a holonomic drive platform sitting atop a 12" diameter sphere. Yup, that is it. At first thought, it sounds fairly easy, but if you think about the technical challenges, it gets pretty deep, pretty quickly.

Fortunately for me, I will have some help. I have been ruing over this idea for a few years now, and it turns out one of my friends, Phil Davis (of Shelob fame), also has some plans and sketches cached away in his underground lair for just such a contraption.

Starting from the ground up, delving deeply as we must into every component and system, you will find that extra special attention must be given to every aspect of the drive system itself. Just the sphere that everything sits atop must be carefully crafted, not to mention the motors, tractive components, and controllers. Imagine the dynamics of a system like that. One slip and it's over. Inertia takes over and you go down.

Take, for example, the lowly ball mouse. Its ball is a thin veneer of high-traction rubber over a steel sphere. Not a solid ball, not a foam ball or an air-filled ball. As simple as it seems,

it is, in fact, a highly engineered product, a composite imbuing it with both the mass and traction characteristics needed.

The construction of the ball balancing robot is actually quite similar: a skin and a core. Like the mouse ball, the skin must be grippy, but not compressible. Unlike the mouse ball, we want the ball to have as little mass as possible. The problem is, I have yet to find an off-the-shelf, 12" diameter, hard rubber, rigid hollow sphere.

The next issue to address is transmitting power from motors to the sphere. Simple wheels won't do, and for the highest performance, we need to ensure that the wheels are always in contact with the sphere. To achieve this perfect union, we intend on using Omni-Wheels™ or their cousins TransWheels™. This will allow the motors to produce driving force on the sphere while ignoring other vectors of motion generated by other motors.

Please understand that this is just the tip of the engineering challenges that lay ahead. I just thought it would be fun to get you thinking on this one aspect of the project without delving in too deep just yet. There is too much to cover in even three or four columns, so for now, I will just lay out a bit of my battle plan as it stands.

Presently, Phil and I are in the resource gathering phase. As you have seen, there are some big engineering challenges that have been identified and some likely solutions. We are in the process of purchasing and evaluating some of the components I think we will likely use, and we are trying to build a few simple prototypes to test some of our ideas.

Top of XPort.



Bottom of XPort.



Sphere Manufacturing

Why all this trouble when we could use a basketball (for instance)? Just fill it up to its maximum pressure, and you're done. Unfortunately, it is still only about 10" in diameter. It is still compressible and it leaks. You could start modifying it — filling it with polyurethane foam for example — but it is still a hack and it still looks like a basketball.

Think about it for a moment. This is the novel part of the whole thing. This is the first thing people see. Any microcontroller worth its salt should be able to handle the basic math at the core of all this, but the looks and functionality of this project all center on the sphere we use.

Without going into hideous detail just yet, I have determined that one could make a mold and build the sphere from the outside in, or one could construct a core and build the sphere from the inside out.

I have done my share of mold making and casting (think full scale P-51 Mustang). I have done enough to know that it is expensive and complicated, not to mention toxic. I have sweated and itched, and I am sure I will live a shorter life for it.

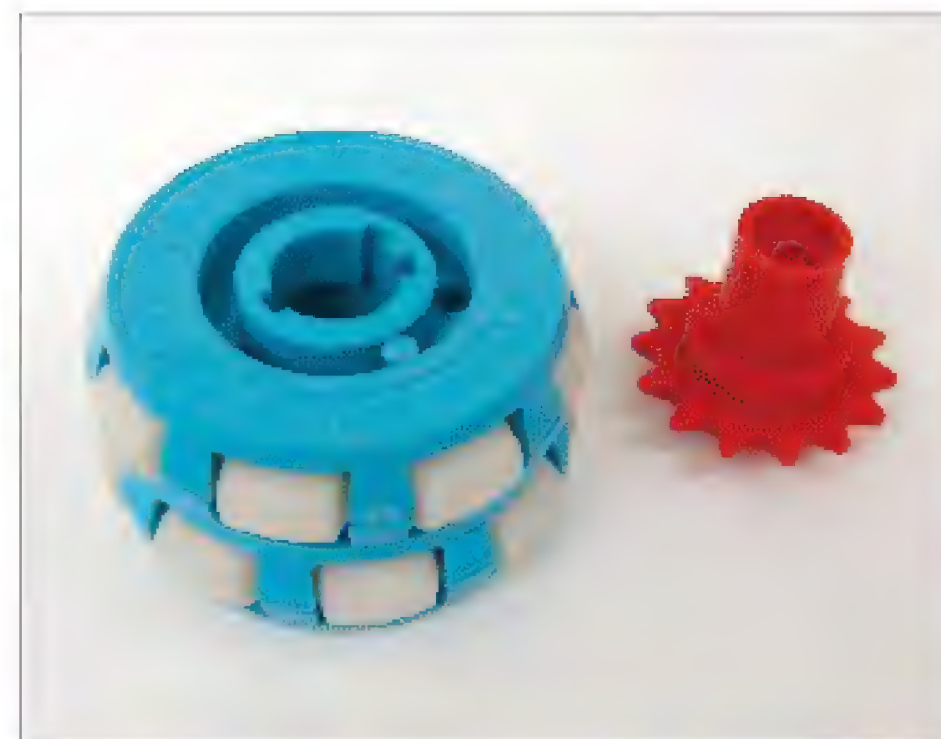
To begin, you need a good sphere, a rigid multipart mold, a removable plug to get inside, and a multi-axis rotational device that you can set turning to slosh the plastic, rubber, and fiberglass slurries around inside your mold (yuck). Mind you, casting spheres layer by layer to build the features you need is appealing, especially when you want to build multiple spheres, but I am going to try another method.

Working from the inside out means I have the control to change the thickness of the various layers more easily; working from the inside out gives me control of the final size.

Following these lines of thought, I have decided to build a multiple axis CNC sphere shaper. I know this sounds complicated, but I have my reasons. They will be revealed, I promise.



Omniwheel mounted to a motor.



TransWheel and Keyed chain drive insert.

As far as materials are concerned, it will be EPS foam (Expanded Poly Styrene) with a fiberglass shell and polyurethane skin. Care will have to be taken to ensure that there are no cross material sensitivities. For example, EPS needs to be sealed from polyester resin or it will melt.

Drive Components

The exact geometry of the drive system is undetermined, but I do know that Phil and I will be using some sort of omni-directional wheel. They are used for conveyor belts and are actually seeing some specialized robot duty. Commonly known as OmniWheels™ or TransWheels™,

some robot stores like www.acroname.com carry them, and they can also be found at industrial suppliers like www.kornylak.com

The final version will likely see something like belt-linked sets of Omniwheels on sprung bogies, captivating the sphere. This should allow it to do some sick enduro action like 360 backside Ollies and some gnarly grinds. Okay, maybe not that robust,

Late Breaking Information

The day after I submitted this column, Phil found this link www.shapeformation.com. They manufacture EPS spheres in a variety of sizes. I purchased two, so we'll see how they work.

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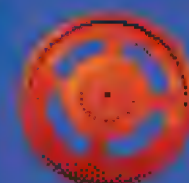
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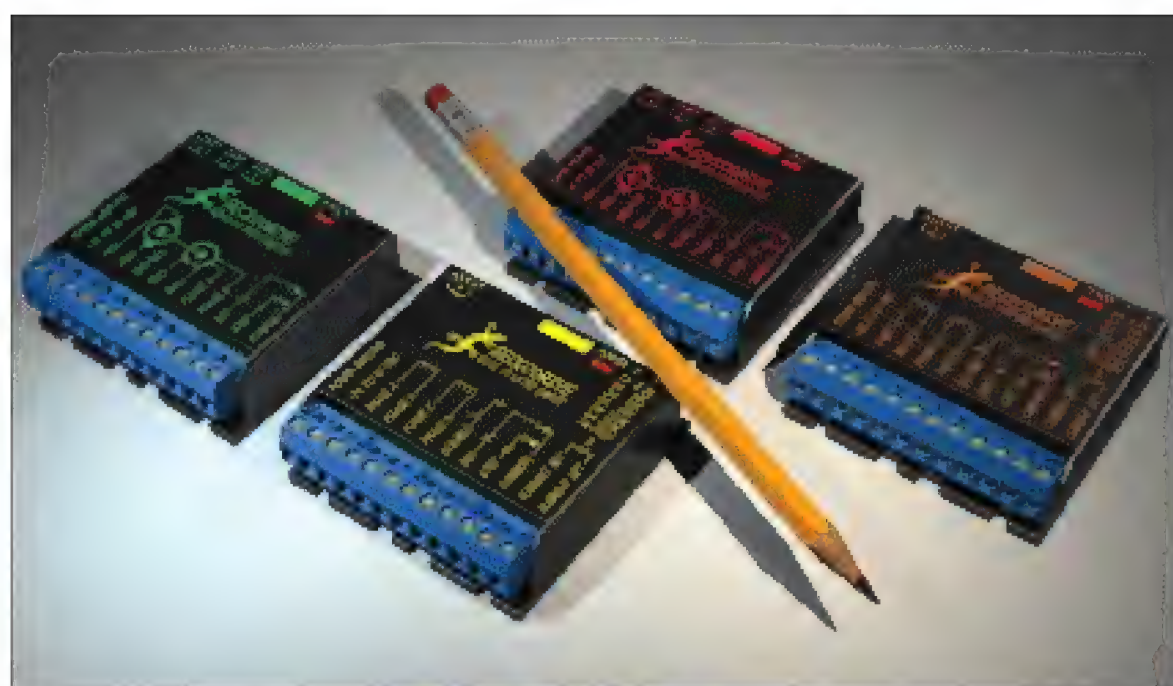


GameBoy Advance with XPort.

but there is a possibility of dropping off small ledges, and I would hate for its top half to bounce off the bottom half. Captivating the sphere is a reasonable design consideration.

Motor Control

This is where things start to get tricky. This will definitely require closed loop motor control. Several companies out there make nice products, however, they all share one thing in common in that they are a sealed system. They use a pre-canned PID



Gecko product line.

algorithm which turns error and commands into velocity information. Many are locked to a particular power driver chip, most are locked to a particular PWM frequency, and all, or nearly all, take only quadrature or analog tachometer feedback.

I happen to have an inside "scoop" into a new product coming out from www.newmicros.com. It is a modular, programmable, trajectory generator with a powerful PID implementation that runs in the background, leaving the foreground for other things.

It is based on their Pod controllers, so there is still plenty of horsepower left over for doing other things. I will also use this as a sensor reading system and run the balance algorithm with it. I may also use it as the main controller, handling all behavioral and mapping functions. I

can at the very least read the pulses from an R/C receiver or serial link and use it as a manual control and balancing sub system, or communicate with it serially via PCI, SPI, or CANbus.

Meanwhile, Phil is looking into using a couple of ARM processors, linked with CANbus or SPI. He is more interested in the

code, I am more interested in the build. Since I basically have most of the code written for the hardware I intend to use, it is sensible to use what I am accustomed to. Phil prefers exploring new processors and control architectures.

Brains

Aside from the possibility of using an IsoPod for the brains, I have been toying with the Gameboy Advance™ (GBA) from Nintendo. This, coupled with the Xport from www.charmedlabs.com and you could do some really interesting things. Aside from the 150,000 gate FPGA on the Xport and the huge power you can wield at your fingertips, plus the massive 16 megabytes of SDRAM, you get a really easy path

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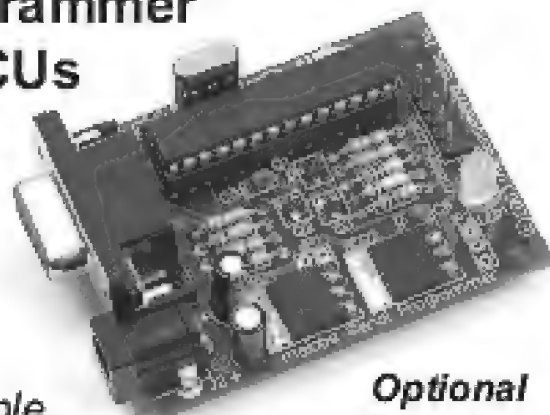
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through the confusing Cygwin, GCC, ARM7 toolchain and an easy method to upload code to the GBA.

The GBA itself is a pretty neat machine and its color display brings me back to the day when graphics could be done with simple writes to screen memory. It does not take a lot of sleuthing to find a lot of information on the web regarding this neat little controller. Just to whet your appetite, think about an \$80.00 controller with color display, 32 bit RISC processor, and lots of memory.

I found a really great online book at www.jharbour.com/gameboy/default.aspx. It never made it to print due to legal issues, however. Nonetheless, this is a well written and highly useful tome. The book centers on the use of something called HAM, which is a library of tools wrapped around GCC. Drop Visual Ham on top of that and you have a really nice development setup. You can even get started without the hardware by using the emulator included in HAM.

CNC

You will recall that I opted to do an entire CNC platform just to save myself the trouble of slinging some goo around to make a casting. If you think about it, the mold is a one-use tool. It makes the sphere size you cast and nothing more. A CNC machine can do many things. At the very least, I can carve different diameter foam cores for my spheres and hopefully grind different tread styles into my outer rubber.

I have decided upon www.deskcnc.com to supply me with a multiple axis CNC controller and software. To drive my motors, I will be using Gecko drivers from www.gecko-drives.com. I am undecided on motors, but I may try my hand at steppers. The folks at Gecko recommend some motors from www.usdigital.com.

It is my intention to build this all on the cheap (relatively speaking), so I will try to build things as flexible as possible. There are a variety of companies out there that make systems of extrusions and angle brackets. For instance, check out www.8020.net. While the initial price is high, if I am intelligent, I can buy a handful of components that I can reuse over and over in different shapes. Mind you, I am not overly concerned with high accuracy, just high utilability.

One thing I hope to achieve is to make the body of the robot out of foam and fiberglass, as well. If I can come up with an intelligent design for my machine and components, I should be able to handle this easily.

Phil already is building some CNC milling gear, so he is set to make our parts. I also have access to a waterjet cutter, and may try my hand at using the services of www.emachineshop.com. Emachineshop is a rapid prototyping service that I have been reading about, and I really don't like cutting fluid or metal chips. Phil is a regular chip monster, so he'll be perfectly happy making little metal bits.

The Battle Plan

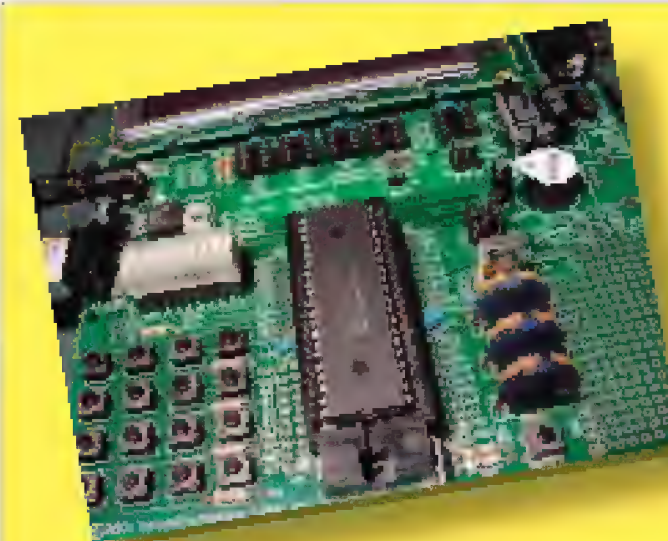
My plan is that in my next column, you will see some progress being made on the drive system. The sphere manufacturing will come, but there is a lot to it, and I cannot afford to be wasting the materials required to make it. I do hope to procure some samples of different rubber compounds, and will attempt to emulate the processes that I hope to use to evaluate the feasibility of all this.

Phil and I will be following separate but similar courses. We each have our own ways of doing things and our own resources. I will be documenting all of our progress for you, and comparing and contrasting our successes and failures. One thing is for sure, this will be an interesting road.

For all I know, my next column will be centered on making paper maché spheres. This all assumes I don't get sucked into writing a game on the new Gameboy ... **NV**



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The Business of Electronics Through Practical Design and Lessons Learned

In The Trenches

Tips and Techniques Revisited

Engineers are often called upon to fabricate and repair equipment themselves. Unfortunately, for many engineers, their only exposure to hands-on work was from laboratory exercises in school. This month, we'll look at some practical approaches to common problems. For experienced hobbyists, some of these may seem obvious.

Through-hole Desoldering

First, two important notes. Be sure that you are officially allowed to work on the equipment. Some programs (in particular military and medical) require that all work be done by qualified people. This is for quality control and traceability. If you're not sure that you're qualified, you probably aren't. Also, if you don't need the component

you are removing, clip the leads and desolder them individually. That's the easiest and fastest method. (This works for many SMT parts, as well.)

The least professional and least safe method is the "whack" method. With this technique, you heat the pad or joint with the soldering iron until the solder is liquid. Then, before the solder has a chance to harden, you whack the printed circuit board (PCB) on the desk. The shock flings the solder from the PCB and onto your desk (and papers, other engineers, and yourself). Never do this around food! Many solders still contain lead which is poisonous if ingested. This method actually works fairly well. Obviously, too big a whack may add to your repair duties.

The "pry" method works for two-leaded components like resistors and capacitors, but it's risky. Heat one leg of the component from the top of the

board and pry that end out of the hole with a screwdriver. Then heat the other lead and remove the component with tweezers. You will still have to remove the remaining solder on the PCB.

Note that this method has the very real possibility of ruining the plated through hole if too much prying is used. The hole-plating can actually be pulled out of the PCB.

The solder-sucker has been around for a long time in various forms. The cheapest is a rubber bulb with a teflon nozzle. You squeeze the bulb, apply it to the melted solder on the PCB pad, and release the bulb. The vacuum caused by the re-inflation of the bulb sucks the solder up the nozzle.

A variation of this is with a spring-loaded syringe-like "pump." Instead of squeezing a bulb, you depress a plunger until it locks. Then, when you are ready to suck some solder, you press a release button and the spring forces the plunger up to create the vacuum. Some versions have a protective extension around one side of the plunger. Others have a fully exposed plunger. The exposed plunger can be dangerous if you're not careful because it pops out four to five inches. If you have your head close to the work to see better, when you release the plunger it may strike you in the face or eye. (This is NOT uncommon.)

I've never had good luck with either of these tools. However, there are combination soldering irons/suckers for about \$25.00. Both the bulb and pump versions are available. They eliminate the need for a third hand and remove the rush to get the tool to the pad before the solder re-hardens. I have a pump-type version that works well. (There are also professional desoldering stations with continuous vacuum.

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“Solder braid” is a common and very effective method (“Solder Wick” is a trade-marked product like “Scotch Tape.”) You place the braid on the pad and the iron on the braid. As the braid heats up and the solder melts, it wicks into the braid. Here are some tips to make it work better.

Use the widest braid that’s practical. This is because the wicking action is limited to a fairly small area. If that area of the braid gets saturated with solder, the whole hole won’t be fully cleared. Use a hot soldering iron. The wicking action works better and the wick acts as a heatsink to cool the iron’s tip. Carefully watch the progress of the solder around the hole. With plated-through holes, it takes an extra few seconds for the heat to conduct to the other side. Patience is a virtue. Sometimes there isn’t enough exposed solder to start the wicking action. The solution is just to add some solder.

With any method, after the solder is removed you must adjust the leads through the center of the hole. If the lead is touching the side of the hole, residual solder can hold it tight.

Desoldering SMT Parts

The only “proper” method of removing SMT (Surface Mount Technology) parts is with an SMT re-work station (which is very expensive). That being said, here are a couple of ways to do it manually. I have seen (but not done it myself) a technician take a standard industrial 1,500 watt hot-air blower and tweezers to remove a high pin-count SMT IC. An air-focusing adapter was used (so a regular hair-dryer probably won’t work). The problem is that the temperature is uncontrolled. This could cause more problems. You can use solder braid to first remove as much of the solder as possible. The only solder left should be that which is actually holding the IC lead to the PCB. Be sure the soldering iron tip is solder free (or it may transfer solder back onto the pad). Then heat the pad/lead junction while using an

X-Acto knife to gently pry up the lead.

When the remaining solder melts, the lead will pop up. Remove the heat but hold the lead up until it cools. Then proceed to the next lead. This approach is time-consuming, but it works fairly well. You will probably have to re-form the leads of the IC. Once you get the knack, you will know how much prying pressure to

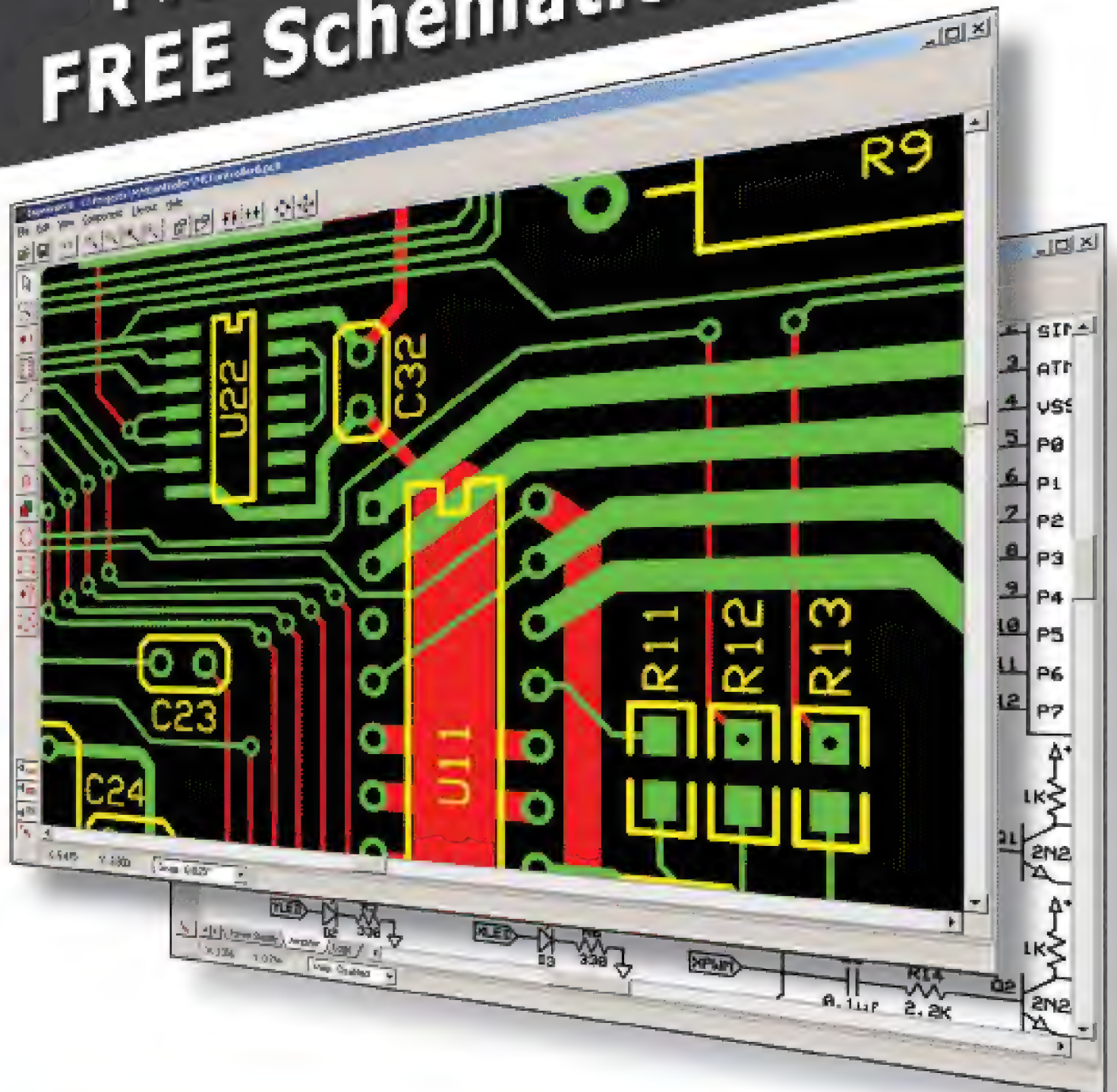
use. Too much prying can lift the pad.

For SMT resistors and capacitors, you can try the “blob” method. Here you add solder to the pads to increase the thermal mass so that it cools more slowly. Then you alternately heat the two ends and use tweezers to remove the component while the solder is still molten. You have to be quick. And, of course, remove the excess solder

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In The Trenches

when you're done. The blob method works for SOT-xx (Small Outline Transistor) and low-count SOIC (Small Outline Integrated Circuit) packages. The trick is to add enough solder to cover ALL the pins on one side. In this way, all those pins will release at the same time. It's pretty crude.

There are also special, low-cost IC removal kits available. These consist of a special "solder" that has poor binding strength. This allows the IC to be pulled off the PCB without damage to either.

Holes in Rounds

It's annoying and frustrating to drill round things. The bit wanders and never actually drills exactly where you want it. With very small holes, this can be enough to snap the bit. The obvious approach of using a center-punch to create a dimple works well, except on thin-walled tubes (which crush with a center punch), plastic tubes (which break), and other products. The "slide-dimple" approach requires a scrap piece of tubing that's about an inch long. First, cut through one side of this scrap lengthwise. Then pry it open slightly. Through this opening, drill a hole of the proper size. Since you are drilling from the "inside-out," the tube's curvature will hold the bit in place. Now you can slide that scrap over the piece you really want to drill (the cut side allows the scrap to expand). Align the scrap's hole to where you want a new hole and drill. The hole in the scrap acts like a dimple to hold the bit in place and eliminate wander.

A somewhat similar approach can be used for threaded-rod. Drill a proper-sized hole through a nut. Then thread the nut to where you want a hole. Drill through the nut's guide-hole and into the threaded-rod. Note this method requires that the guide-hole be perfectly aligned with the drill bit and also centered on the rod. To keep everything stable, you can put a lock-washer and tighten another nut next to the hole-guide-nut.

The "slide-guide-hole" approach is very similar but works for tubing rather than threaded-rod. Here, you

take a solid block of material (wood, plastic, metal) and drill a hole through it that is the same diameter of the tubing you want to drill (this block becomes your "nut"). Then, using the proper size bit, you drill another hole (from a different block face) so that it intersects this hole. When you slide this onto your tubing, you will have a guide-hole that you can move back and forth and align with your work, which prevents wander. A simple method that sometimes works is to drill a properly-sized hole in a flat plate and use it like a "slide-dimple" above. The problem is that you must clamp the plate firmly in place as you drill. Using your hand to hold it doesn't work well.

Schottky is Better Than Germanium

There are often occasions where a diode's V_f (Forward Voltage drop) is an important factor. Standard silicon diodes are typically said to have a 0.7 Vf. Germanium is said to have 0.3 Vf. I use the word "said" because that's what I read in most articles. It's only partially true. At rated power, these values are reasonably accurate for generic diodes. But let's look at measured low-current (about 0.5 mA) values.

A 1N914 silicon diode comes in at 0.60 Vf. A 1N4002 (silicon) is measured at 0.42 Vf (that surprised me, too). A germanium 1N60 had a Vf of 0.26. The "Fast Schottky Barrier Diode," type 1N5819 had a Vf of only 0.17. This is 65% of the germanium type. Germanium also has poor reverse resistance when compared to silicon. The actual rating of the Schottky diode is 0.6 Vf. That's under a full one-amp load. Schottky diodes are typically used for "spike" removal in power-control circuits. I think that's why few engineers consider them for low-power applications. They do have many nice features.

The 1N5819 costs about \$0.68 (single unit price), can handle one amp continuously, and has a PIV (Peak Inverse Voltage) of 30 volts (that's not very good). It comes in a standard epoxy diode package. There are a large number of Schottky diodes avail-

able. Look around for one that fits your needs. Remember that the Vf increases with increasing current. So diode comparisons should consider this.

Switch/Relay Selection

Switch and relay selection seems like such a simple thing but it causes so many problems. The single most important factor for any switch or relay is the contacts. It's the contacts that do the actual switching. Yet it seems that this critical characteristic is overlooked with regularity. There are two basic contact materials for common panel switches: silver and gold.

Silver is used for relatively high-current and/or high voltage applications. The reason is very simple: silver tarnishes (or oxidizes). This tarnish is an insulator. High current and/or high voltage switching invariably causes a spark to form at the contacts when they open or close. This spark blasts through the thin oxide layer and allows a good electrical contact. If there is no spark, the tarnish builds up until the switch or relay fails to operate properly. Silver contacts should NEVER be used for low current and low voltage circuits. There is a single exception to this rule. It is possible (but not recommended) to use silver-contacts with a rotary switch. This is because the sideways movement of the contacts rubs off the oxide layer. This demands that the switch be used with regularity in normal operation. Old TV tuners often used silver contacts to save money. (And the users often had to work the switch back and forth to make it operate properly. Switch-cleaning made a lot of money for TV repairmen. Some TVs even had holes to apply contact cleaners.)

Gold contacts are used for low voltage and/or low current applications where a spark is NOT present. Typically, the contact body is solid silver with a thin layer of gold plated onto it. Gold is an expensive material, so it is used sparingly. The problem is that if a spark does occur, it can blast away the thin gold plating down to the silver. Now you're back to silver con-

tacts that tarnish. For "dry" switching, that is extremely low voltage and/or current, mercury-wetted contacts may be needed. These are now only found in sealed reed-switches because mercury is hazardous. (Even these switches are getting hard to find.)

Mercury has the great feature of making reliable electrical contacts without any contact pressure. It flows into itself from one contact to the other. But mercury can't handle high voltages because the vapor can break down and when it does, your switch becomes an ultra-violet lamp. Nowadays, dry switching is usually handled with solid-state switches (like the old CMOS 4066 IC).

Chemicals

Cleaning requires chemicals and different chemicals clean differently. For plain grease and grime that you find on well-used knobs, controls or surface panels, a surfactant is useful.

A typical surfactant is "Fantastik."

Alcohol is good for contact cleaning. However, make sure you use isopropyl alcohol. Do not use rubbing alcohol. It can contain oils that remain on the contacts that can cause dirt build-up. A quick test is to wipe some on a clear piece of glass and let it evaporate. If there is any oily residue, don't use it. Note that alcohol is very good at removing aluminum marks.

Acetone is quite powerful and chemically reactive. It's good at removing adhesives. It's also good at ruining the finish on plastics. Be careful where you use it. You can get pure acetone at any hardware store. Using nail-polish remover (mostly acetone) can cause problems because there are often added oils to reduce skin drying. These remaining oils attract dirt. It's always a good practice to use alcohol to re-clean anything you used acetone on. This removes any residual acetone (which is chemically reactive) and oils.



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Custom Metal Shapes

So you really need a 3/16" spacer, right now, and you don't have any. Take some bare #22 wire and tightly wrap it around a pencil (or drill bit of the proper size) until you have a coil that's 3/16". Now, twist the ends together to hold everything in place and remove it from the form. Next, solder the whole coil, except for the twisted ends. After it cools, remove the twisted ends and you have a 3/16" metal spacer. True, the metal isn't very strong. But, for many applications, it's strong enough. You can do a lot with this wire and solder technique. It's fast and cheap. Use your imagination.

Weak Batteries

There is a huge difference between a circuit working at a reduced voltage and one working from weak batteries. This is because the internal resistance increases with weak batteries but remains the same with a standard power supply. This difference can have significant effects on your circuit.

You should always use this test

with any circuit that is expected to operate on batteries. You say you don't have any weak batteries on hand? No problem. Just insert a 50 to 100 ohm resistor in series with your circuit. Then adjust your power supply to provide the desired voltage at the circuit. Obviously, be sure the resistor is rated properly so it doesn't smoke.

This test is very useful because it will show how stable your circuit is. A weak power supply is much easier to disrupt. This is because of the higher internal resistance. It's easier to make the voltage change in a high-resistance circuit than a low-resistance one.

Noise spikes or voltage sag will be much more pronounced when working with weak batteries. Often times, there are simple solutions that you can implement to improve matters. This means that you are directly improving the reliability of your circuit. Few tests allow you to do that. What's more, for battery operated circuits, you can truly estimate the battery life. And, of course, if you can improve its performance with weak batteries, you've increased the usable battery life.

Quick Tips

Put a small rubberband across the

grips of your pliers to make a self-closing tool. It's great for holding small parts and circuit boards for soldering.

Some blank video tapes come with peel-off/stick-on letters and numbers to identify tapes. These letters and numbers have lots of other uses. I use them to identify floppy and hard drive designations. Since I use multiple computers, I often forget which is which.

Those plastic storage cabinets with lots of small drawers are great. But look around in the hardware section before you buy. I've found that these same cabinets filled with hardware (screws/nuts) can be much cheaper than the empty ones. I also label the drawers with 1/2" by 3/4" labels from the office supply store. These labels are nice because they can be removed easily and everything writes on them. "Corrugated bins" — those cardboard boxes with the sloping front and open tops — are very handy. (Plastic versions are good, but more expensive.) They're often available as company supplies or in the production department. However, if you like microwave popcorn (or know someone who does), they're free.

These bins are invaluable for keeping multiple projects organized. Usually you can store parts, supplies, and documentation for a whole project in one box. It's quick and easy to put all the parts in one bin when you need to stop work. And it's just as quick and easy to start working again. Keeping things organized cannot be overstated.

I put a magnet on my drill press to hold the chuck key so I don't misplace it and waste time searching. However, do NOT use a magnet to hold drill bits. They can become magnetized. If this happens, when you drill iron or steel, chips will remain at the tip instead of being moved up the flutes. This will lead to bit-binding and breakage.

Conclusion

These are things you learn from doing. But for many new engineers, hands-on experience may be minimal. Hopefully, you found a new tip. You can also refer to the December 2003 issue of *Nuts & Volts* for additional tips. **NV**

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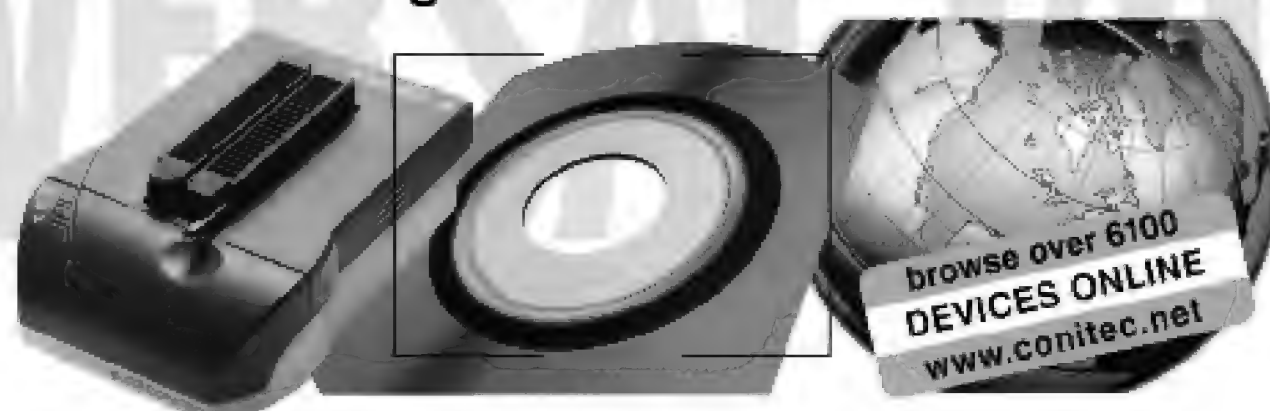
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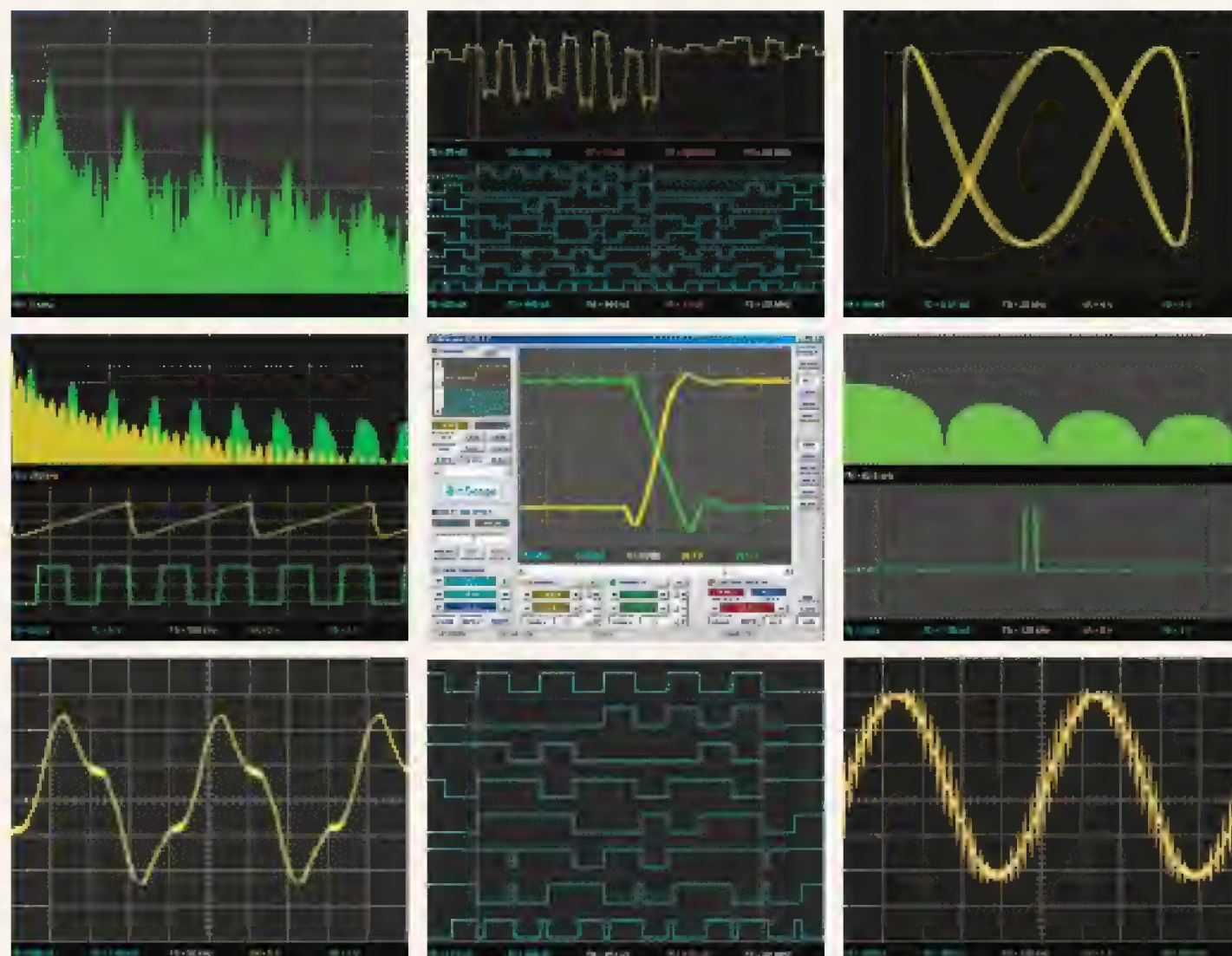
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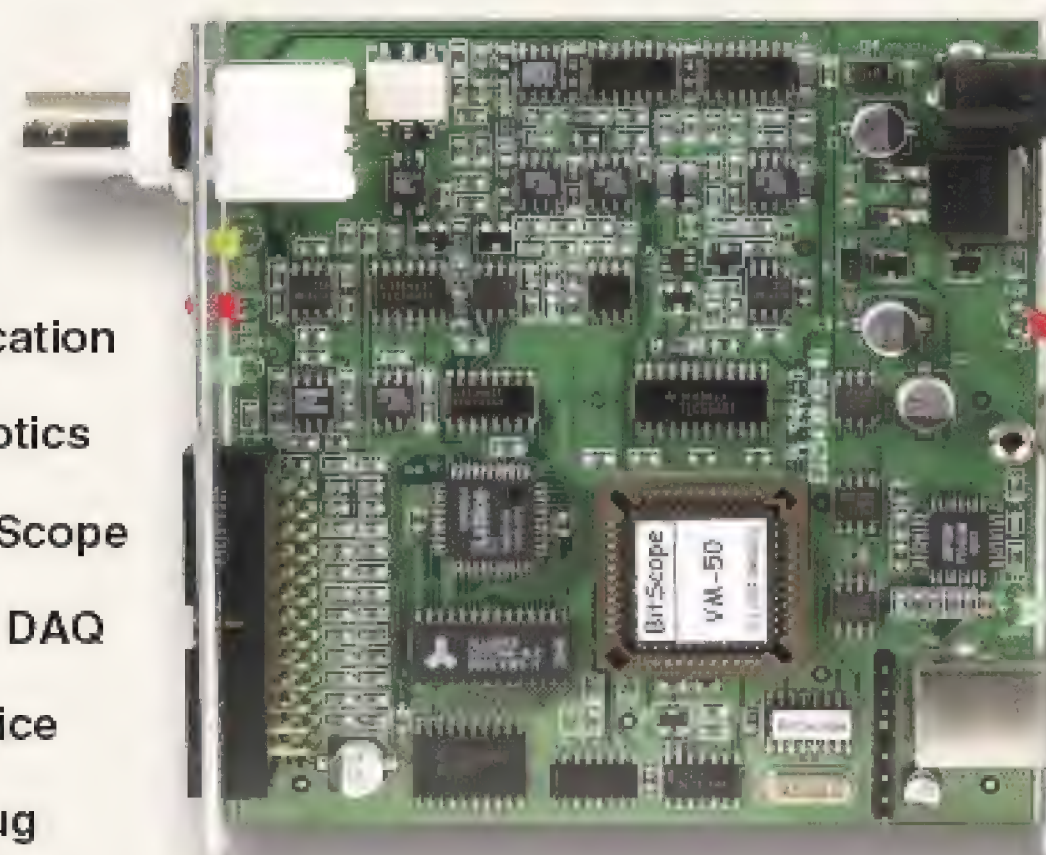
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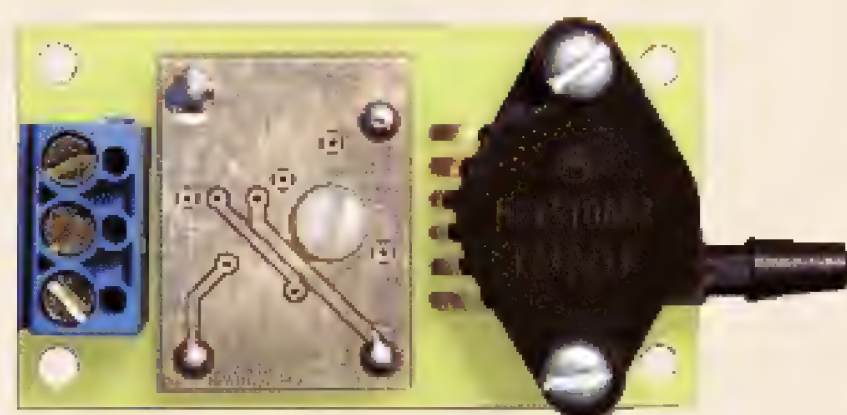
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New Product News

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TRANSOLVE

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Web: www.transolve.com

Circle #77 on the Reader Service Card.

FIRST MAGNETICALLY-BASED WIRELESS ACCESSORIES FOR TWO-WAY RADIOS

FreeLinc and Aura Communications (Wilimington, MA) have introduced the world's first line of wireless accessory products for two-way radio communications. Users of two-way radios will now be able to 'cut-the-cord' and enjoy untethered communications through FreeLinc's family of products. These products include wireless headsets and wireless speaker microphones — all of which are based on Aura Communications patented LibertyLink® magnetic induction technology. Aura's technology allows for secure wireless communications that are immune to interference from Bluetooth™ or WiFi® devices, making FreeLinc's new product line ideally suited to the specific needs of the two-way radio market.

"FreeLinc is a pioneer in this market niche," said Tony

Sutera, FreeLinc's chief executive officer. "Our patent pending technology is the first of its kind and will greatly benefit users of two-way radios through greater freedom of movement, ease-of-use, and increased safety. Many of our products will also feature Voice Operated Transmission (VOX) which will allow unprecedented hands-free communication in the push-to-talk radio world."

FreeLinc has partnered with Aura Communications to utilize the company's LibertyLink near field magnetic communication technology. Unlike Bluetooth and other traditional radio frequency technologies, LibertyLink enables a secure, reliable, and easy-to-use wireless accessory solution for two way radio applications.

FreeLinc will first be offering the FreeMotion 200, which is a lightweight, durable earpiece that contains a speaker, a boom microphone, and both push-to-talk and VOX features. The FreeMotion 200 will be available in July 2005. This flagship product will quickly be followed up by the FreeMic 200, a wireless lapel speaker microphone, and the FreeRange 200, a dual ear-muff headset, both to be available in Fall 2005.

For more information, contact:

FREELINC

Web: www.freelinc.com

Circle #81 on the Reader Service Card.

Surplus Sales of Nebraska

BAM - SAM - RAM for the HAM | Badger Omni-Remote Network Monitoring System

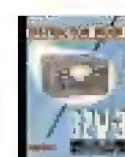
\$549

Do you operate a remote base? A repeater? A packet forwarding system? Do you have a vacation home you would like to monitor remotely? Almost any remote control application. Start and monitor a generator remotely. 100's of uses!!

There are many occasions when it is desirable to collect data and alarms from remote sites or even have real-time control over security. Particularly suitable for telcos and wireless operators, where for example remote cell site monitoring can now be achieved in a cost effective manner, the Badger OmniRemote is a highly flexible unit that allows all this and more in a simple to install 1U format. There are three module types. The Bistate Analogue Module (BAM) that has either 16 or 64 inputs, the Serial Alarm Module (SAM) with two or 10 inputs and the Remote Access Module (RAM).

Connect to the outside world via DSL, phone line or radio modem. The OmniRemote accepts analog, TTL, voltage and dry contact inputs to report status of alarm systems, weather monitors, radios, computers and networks; virtually any analog digital or mechanical device. It can also be controlled to open or close dry contacts, route data to other inputs and control external devices. See our website for other possible configurations and uses for the Badger Omni-Remote.

Please visit our website with over 2,000 pages and 10,000 images • www.surplussales.com



HI Manuals: 1,000s of radio, military and test equipment manuals on hand!!



Semi-Conductors: Diodes, transistors, transient suppressors.



Transformers: Sealed, Open Frame, Audio, Switching, Pulse, High Voltage



High Voltage Power Supplies



Copper Clad Circuit Board: Single, Double-Sided.



Vacuum Tubes: Over 1,000,000 vacuum tubes in stock!!



Rotary Inductors: 100 watt to 10kw. Manual and motorized



Ceramic Transmitting Capacitors: Of All Sizes: Doorknobs-Feedthru-Water Cooled



Collins Parts: For Amateur and Military.



Marine Instruments: Antique Stadimeter.



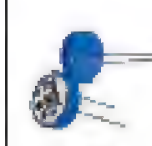
Metal Film Resistors: Over 4,000 values in stock!!



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"Based on experience, I can tell you that Rabbit stuff works before you can get it all out of the box."

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The Core of your Embedded System

The PowerCore FLEX is a complete Rabbit microprocessor system with optional features such as a power supply, Ethernet, and a low-cost rugged A/D system. It plugs into a motherboard you design. You pay only for the options you need, and we quickly manufacture it. Development Kits include a powerful software development platform and extensive libraries.

Network and Internet Support

Your embedded device can network and serve web pages. Hardware and software supports Ethernet, Wi-Fi, and cellular telephone data networks. TCP/IP and most associated protocols are included in the Development Kit. SSL secure server software and other premium software modules are available at a nominal cost. With the implementation of optional software modules such as RabbitWeb, SSL, PPP, and AES, you can securely and conveniently communicate with your embedded device from anywhere in the world.



Development Kit Includes

- A loaded PowerCore FLEX with all options or non-Ethernet low-end version
- Prototyping board with development area.
- Documentation on CD.
- Dynamic C integrated development environment.
- Serial cable, power supply, and more.



Kits From
\$129

Free Reference Book With Kit!

"Embedded Systems Design using the Rabbit 3000 Microprocessor" free with PowerCore kit purchase.

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qty. 5000 What You Need

Configurable Features

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- On-Board Power Supply
- SRAM / Flash
- Serial Data Flash
- Ethernet Option
- A/D Converter System
- Battery-Backed SRAM



Standard Features

- 39 General Purpose I/O
- 5 Serial Ports
- Real-Time Clock
- Watchdog / Supervisor

* *Pervasive Internet: Embedded devices providing internet connectivity for commercial and industrial applications. Learn more at www.rabbitflex.com*

RABBIT
Semiconductor



2932 Spafford Street, Davis, CA 95616
Tel 530.757.8400

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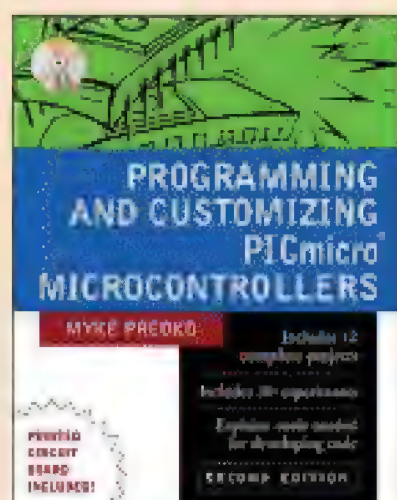
The Nuts & Volts Hobbyist Bookstore

Microcontrollers

Programming & Customizing PICMicro Microcontrollers

by Myke Predko

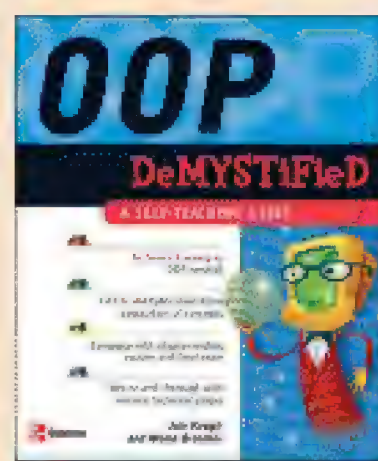
This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicros' hardware architecture and software schemes will complement the host of experiments and projects making this a true "learn as you go" tutorial. New sections on basic electronics and basic programming have been added for less sophisticated users, along with 10 new projects and 20 new experiments. The CD-ROM contains all source code presented in the book, software tools designed by Microchip and third party vendors for applications, and the complete data sheets for the PIC family in PDF format. **\$49.95**



OOP Demystified

by James Keogh / Mario Giannini

Learn object-oriented programming in no time with help from this easy-to-understand guide, ideal for novice and expert programmers alike. Learn about attributes and methods, inheritance, polymorphism, real-world and case modeling, object-oriented programming languages, and much more. Each chapter ends with a quiz, culminating in a final exam at the end of the book so you can test your knowledge. **\$19.95**



Robotics

Mechatronics for the Evil Genius

by Newton C. Braga

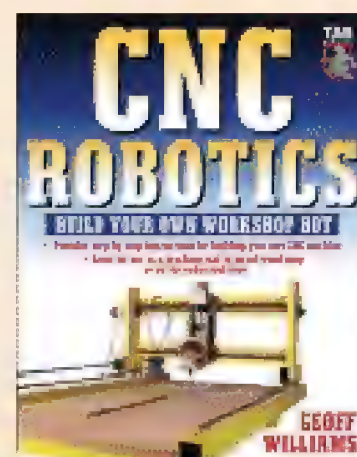
The popular evil genius format provides hobbyists with a fun and inexpensive way to learn Mechatronics (the merger of electronics and mechanics) via 25 complete projects. The projects include a mechanical race car, combat robot, ionic motor, electromagnet, robotic arm, light beam remote control, and more. Also included are parts lists and a tool bin for each project. *Mechatronics for the Evil Genius* covers all the preparation needed to begin building, such as how to solder, how to recognize components and diagrams, how to read a schematic, etc. **\$24.95**



CNC Robotics

by Geoff Williams

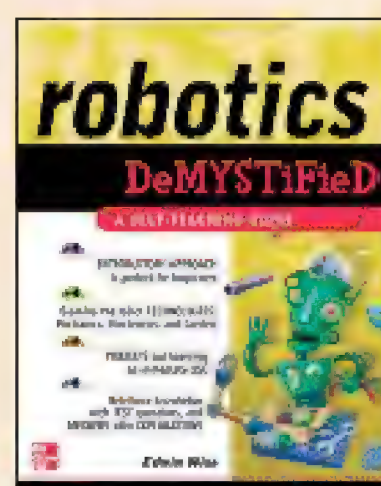
Written by an accomplished workshop bot designer/builder, *CNC Robotics* gives you step-by-step, illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80% of the price of an off-the-shelf bot — and can be customized to suit your purposes exactly because you designed it. **\$34.95**



Robotics Demystified

by Edwin Wise

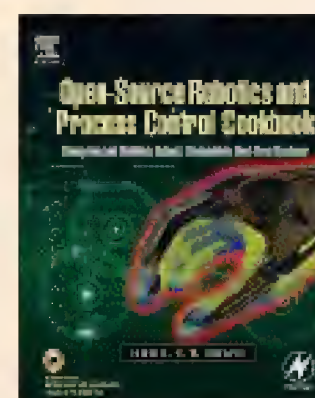
McGraw-Hill's *Demystified* titles are the most efficient, interestingly written brush-ups you can find. Organized as self-teaching guides, they come complete with key points, background information, questions at the end of each chapter, and even final exams. This complete self-teaching guide takes an introductory approach to robotics, guiding readers through the essential electronics, mechanics, and programming skills necessary to build their own robot. **\$19.95**



Open-Source Robotics and Process Control Cookbook

by Lewin Edwards

In this guide, Lewin Edwards demonstrates efficient and low-cost open source design techniques, covering end-to-end robotic/process control systems using Linux as the development platform, with extensive information on free compilers and other tools. Specifically, the book targets development of real-time physical system controls using Atmel AVR microcontrollers communicating with Linux-based PCs for overmonitoring. Code examples are given to provide illustrations of tasks described in the text. The CD-ROM contains all the code used in the design examples, as well as useful open-source tools for robotics and process control system design. **\$49.95**

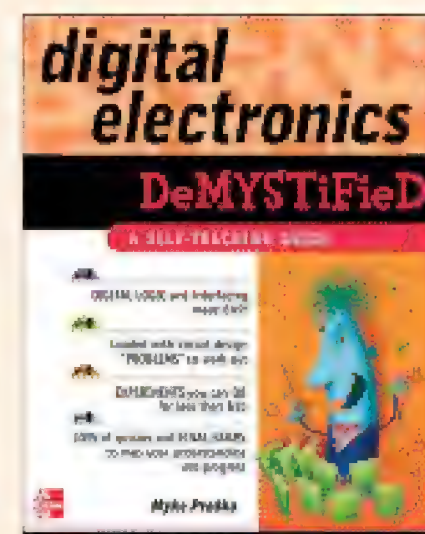


Electronics

Digital Electronics Demystified

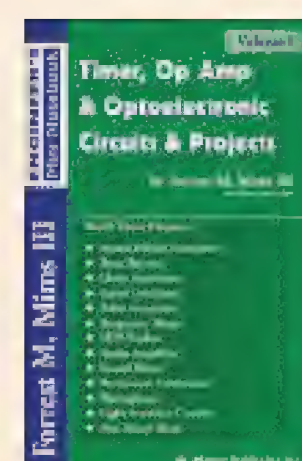
by Myke Predko

Now, anyone can gain a deeper understanding of digital electronics — without formal training, unlimited time, or a genius IQ. In *Digital Electronics Demystified*, electronics expert and author Myke Predko provides a totally painless way to learn enough digital logic and electronics to build your own projects! With *Digital Electronics Demystified*, you master the subject one simple step at a time — at your own speed. This unique guide offers problems at the end of each chapter and section to pin-point weaknesses and a 100-question final exam to reinforce the entire book. So, if you're looking for an enjoyable route into digital logic and electronics, let *Digital Electronics Demystified* be your shortcut! **\$19.95**



Engineer's Mini Notebook Collection

by Forrest M. Mims III



Volume 1 features more than two dozen 555 timer circuits that you can build. **\$12.95**

Volume 2 — Study rain, lightning, clouds, sunlight, water, temperature, and much more! **\$12.95**

All Four Volumes \$46.00 (NV subscribers ONLY!)



Volume 3 — Learn about important sensors and use them to build circuits and projects. **\$12.95**

Volume 4 includes frequently used electronic formulas, tables, circuit symbols, and more! **\$12.95**

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Practical Electronics for Inventors

by Paul Scherz

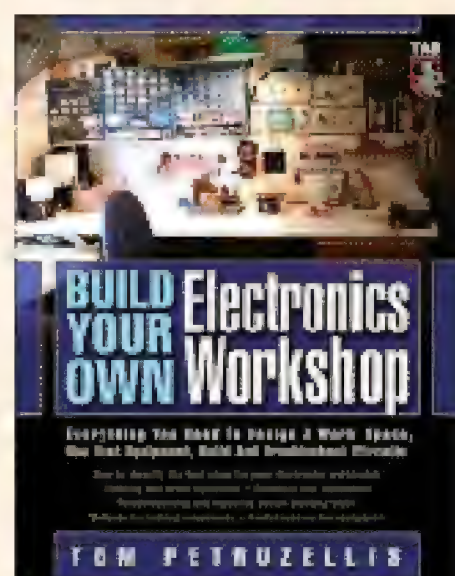
The first edition of *Practical Electronics for Inventors* was phenomenally successful and popular among electronics hobbyists and "tinkerers." This is a fairly "tight" group, and when they noticed some errors in the book, they were fairly vocal in wanting to see errata. The result? A new and improved book that has been completely updated, with several readers' suggestions for improvement incorporated inside. These new additions will make this title even MORE appealing to the loyal market. **\$39.95**



Build Your Own Electronics Workshop

by Thomas Petruzzellis

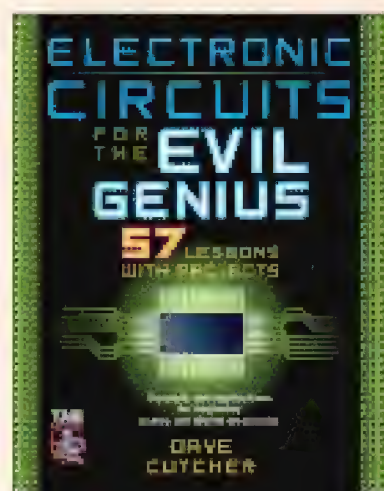
The Electronics Workbench was created to assist the newcomer in the field of practical electronics through the creation of a personal electronics workbench. It is a place specially designed so that readers can go there to work on an electronic project, such as testing components, troubleshooting a device, or building a new project. The book includes invaluable information, such as whether to buy or build test equipment, how to solder, how to make circuit boards, how to begin to troubleshoot, how to test components and systems, and how to build your own test equipment, complete with appendix & resources, etc. This is *THE* book for anyone entering the field or hobby of electronics. **\$29.95**



Electronic Circuits for the Evil Genius

by Dave Cutcher

In *Electronic Circuits for the Evil Genius*, the reader gains valuable experience in circuit construction and design and in learning to test, modify, and observe results. Bonus website www.boks.mcgraw-hill.com/authors/cutcher provides animations, answers to worksheet problems, links to other resources, WAV files to be used as frequency generators, and freeware to apply your PC as an oscilloscope. **\$24.95**



Basic Electronics

by Gene McWhorter / Alvis J. Evans

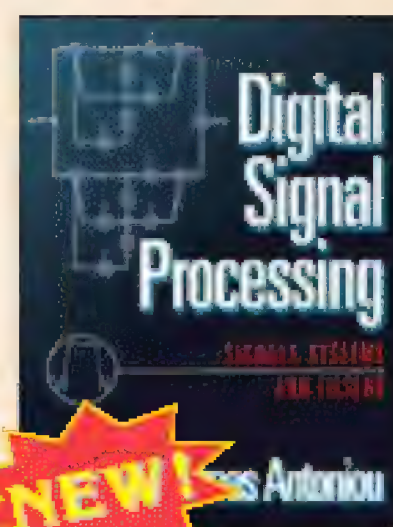
Wouldn't you like to know about the electrical or electronic effects which, many times, we can neither see nor feel? Find out how electronic circuits are used to amplify, transmit, receive and detect signals, or make decisions, or are combined to make computers, controllers, and memories. *Basic Electronics* explains electronic fundamentals using easy-to-read, easy-to-understand explanations coupled with detailed illustrations. It brings seeing and doing together for a very meaningful learning experience, and delivers practical applications at the same time. This book contains worked-out examples within the text to solidify understanding of specific ideas, and quizzes and problem sets at the end of each chapter to complete and reinforce the learning cycle. Basic concepts, device and circuit fundamentals, and circuit applications provide full-scope coverage of electronics in 11 chapters. **\$19.95**



Digital Signal Processing

by Andreas Antoniou

Digital Signal Processing — an up-to-the-minute textbook for junior and senior level signal processing courses and senior/graduate level digital filter design courses — uses MATLAB and the CD-based DSP Lab to allow students to interactively learn the fundamentals of DSP and filter design. **\$115.00**



Home Computing

USB Complete, Second Edition

by Jan Axelson

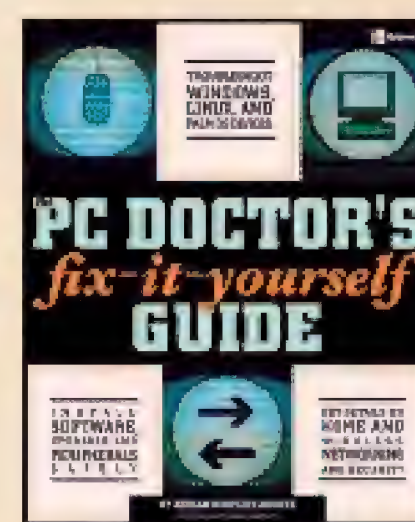
Every recent PC has Universal Serial Bus (USB) ports. In *USB Complete*, Jan Axelson shows how to design and program devices that use USB to communicate with PCs. Learn how to select a USB controller chip that fits your project and budget, how to write program code to manage USB communications in your device, and how to write Visual Basic and Visual C++ applications that exchange data with your devices. Explore how the interface works from the ground up and learn how to create devices that communicate reliably with all PCs. **\$49.95**



The PC Doctor's Fix It Yourself Guide

by Adrian Kingsley-Hughes

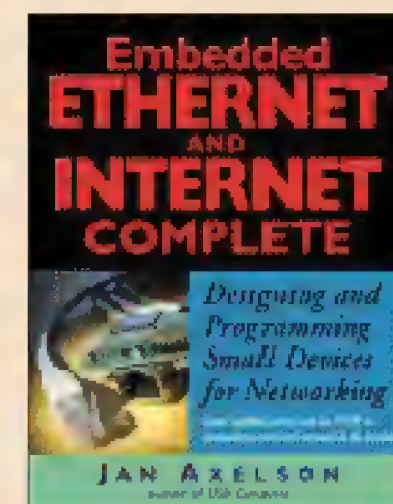
In *The PC Doctor's Fix It Yourself Guide*, you get advice and solutions for solving a myriad of PC problems, including expert tips on researching solutions on your own. Learn how to maintain your computer, keeping it in good working condition, and how to upgrade and install new software safely. Troubleshoot Linux, Windows, and personal devices, use the Internet effectively as a problem-solving tool, get up to speed on computer security, and set up small home and wireless networks. The companion website provides additional support. **\$29.99**



Embedded Ethernet and Internet Complete

by Jan Axelson

Learn how to design and program devices that host Web pages, send and receive e-mail, and exchange files using FTP. Put your devices on the Internet and monitor and control your devices from across town or around the world. Or create private, local networks that enable your devices to share information, send commands, and receive alarms and status reports. Plus: learn about Ethernet controllers, hardware options for networks, networking protocols, and how to keep your device firmware and data secure. **\$49.95**

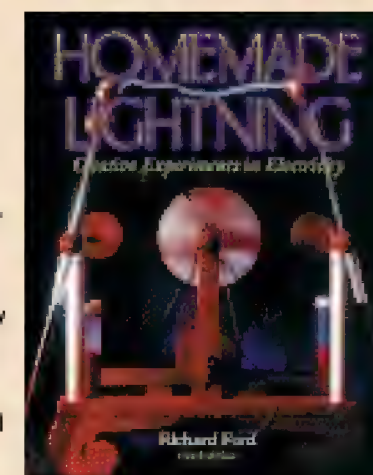


High Voltage

Homemade Lightning: Creative Experiments in Electricity

by R. A. Ford

Enter the wide-open frontier of high-voltage electrostatics with this fascinating, experiment-filled guide. You'll discover how to make your own equipment, how electricity is used in healing, and how experiments in high potential physics work! **\$24.95**



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listing of the titles available.**

Audio/RF Signal Generator

- ✓ DDS and SMT technology!
- ✓ 0 Hz to 5 MHz at 0.1Hz resolution!
- ✓ 0 to 10V peak to peak output level
- ✓ Sine, Square, or Triangle waveform

Following our world famous SG550, we are proud to introduce the SG560, the next generation signal generator!

To begin with we increased the frequency range all the way up to 5MHz and all the way down to 0Hz (yes, we mean zero...or DC!) continuously in 0.1Hz steps across the entire range! Then we gave it a variable output level all the way up to 10V peak to peak in either Sine, Square, or Triangle waveforms! You can also provide a DC offset to the output to recreate TTL, 4000 series logic levels, low voltage logic levels, AC waveforms with a DC component, or just plain AC signals!

SMT and DDS technology is used throughout the SG560 for ultimate performance and reliability. If you're looking for a lab quality sig gen at a super hobbyist price, the brand new SG560 fits the bill...and a whole lot more!

SG560WT Audio/RF Signal Generator, Factory Assembled

\$329.95

NEW!



Hand Held Digital Scope With DVM Readout

- ✓ Digital waveform and measurement display!
- ✓ 10MHz and 40MHz sample rates!
- ✓ Backlit LCD display
- ✓ RS232 output (40MHz model only)
- ✓ Charger, case, probes included

We've seen a lot of portable scopes and scope/meters, and we've also seen the price tags! They have always been way out of the reach and budget of the hobbyist. No more! Now for close to the price of a good DMM you can have a personal scope that also has DVM readout for dBm, dBV, DC, and True RMS! Frequency readout is also displayed on the screen through markers, plus the scopes have two memories for digital storage.

The 40MHz model also includes an RS232 output and serial interface to capture the screen display on your scope to your PC at the mere push of a button! These scopes run on 5 standard AA Alkaline batteries (not included) which provide up to 20 hours of use. You can also use rechargeable AA NiMH batteries instead and they'll be charged with the included power supply! Both units come with a custom foam lined high impact carrying case, set of high quality scope probes, AC power adapter and a comprehensive user's manual. If you're working with electronic circuits, automotive applications, audio and stereo applications or other applications, the personal scope is for you...at a price that can't be beat!

HPS10SE Personal Handheld 10MHz Digital Scope
HPS40 Personal Handheld 40MHz Digital Scope w/RS232
PS28 9VDC Power Supply/Charger

\$229.95

\$299.95

\$9.95

NEW!



Dual Display DMM With RS232 Output

- ✓ RS232 output to your PC!
- ✓ Digital and analog bargraph display
- ✓ Backlit LCD display with data hold
- ✓ Manual and auto ranging
- ✓ Includes probes, RS232 cable, & software

We gave you an inexpensive pocket DMM for under 20 bucks. Then we gave you a super multi-purpose professional multimeter that measured virtually everything for 40 bucks. What's next, you ask? You won't believe it! Everything PLUS RS232 serial data output for connection to your PC! That's right, now you can measure, control, and store your DMM and its readings on a graphical display on your PC!

Features both auto and manual ranging with a large 3 3/4 digit display with a 38 segment analog bargraph. Selectable backlight and data display hold features are also included. Plug in the provided DB9 serial cable to your PC, load the included software, and you're off and running with a remote control digital multimeter from your PC! Includes standard test probes, temperature test probes, professional rubber holster, RS232 cable, installed 9V battery, Windows software CD, all in a neat travel case.

DVM345DI Dual Display DMM With RS232 Output

\$84.95

NEW!



Sniff-It RF Detector Probe

- ✓ Use with any DMM or VOM to measure RF!
- ✓ Low cost RF measurement!
- ✓ Can also be used as a field strength meter
- ✓ 100kHz to 1000MHz!

The RF1 is a very sensitive RF detector probe that connects to any digital multimeter and provides a DC voltage output from weak RF signals. This allows very easy tracing of low level RF signals that a counter can not pick up. Wide frequency coverage of 100 KHz to over 1000 MHz lets you track down most any problem in transmitter chains, receiver stages, or even complex PLLs.

Uses exotic, low barrier microwave detector diodes to give exceptional sensitivity which can see signals down to microwatt levels! A great low cost way of checking for RF. Fully assembled and tested, and includes standard banana plugs for use with any standard VOM, DMM or voltmeter. If you need to measure RF and don't want to spend big bucks, here you go!

RF1 RF Sniff-It Probe

\$329.95



Mini-Kits... The Building Blocks!

Tickle-Stick

The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC

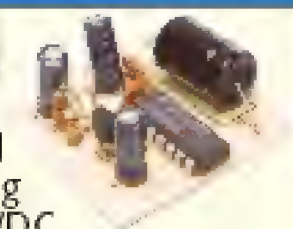


TS4 Tickle Stick Kit

\$12.95

Super Snoop Amplifier

Super sensitive amplifier that will pick up a pin drop at 15 feet! Full 2 watts output. Makes a great "big ear" microphone. Runs on 6-15 VDC



BN9 Super Snoop Amp Kit

\$9.95

Dripping Faucet

Produces a very pleasant, but obnoxious, repetitive "plink, plink" sound! Learn how a simple transistor oscillator and a 555 timer can make such a sound! Runs on 4-9 VDC.



EDF1 Dripping Faucet Kit

\$9.95

LED Blinky

Our #1 Mini-Kit for 31 years! Alternately flashes two jumbo red LED's. Great for signs, name badges, model railroading, and more. Runs on 3-15 VDC.



BL1 LED Blinky Kit

\$7.95

Touch Tone Decoder

Strappable to detect any single DTMF digit. Provides a closure to ground up to 20mA. Connect to any speaker, detector or even a phone line. Runs on 5 VDC.



TT7 DTMF Decoder Kit

\$24.95

Electronic Siren

Produces the upward and downward wail of a police siren. Produces 5W output, and will drive any speaker! Runs on 6-12 VDC.



SM3 Electronic Siren Kit

\$7.95

Universal Timer

Build anything from a time delay to an audio oscillator using the versatile 555 timer chip! Comes with lots of application ideas. Runs on 5-15 VDC.



UT5 Universal Timer Kit

\$9.95

Voice Switch

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch, or to turn on a recorder or light! Runs on 6-12 VDC and drives a 100 mA load.



VS1 Voice Switch Kit

\$9.95

Tone Encoder/Decoder

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Runs on 5-12 VDC and will drive any load up to 100 mA.



TD1 Encoder/Decoder Kit

\$9.95

RF Preamplifier

Super broadband preamp from 100 KHz to 1000 MHz! Gain is greater than 20dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.



SA7 RF Preamp Kit

\$19.95

Touch Switch

Touch on, touch off, or momentary touch hold, your choice! Uses CMOS technology. Runs on 6-12 VDC and drives any load up to 100 mA.



TS1 Touch Switch Kit

\$9.95

Where The Fun Begins!

The Newest Neatest Stuff!

Ion Generator

- ✓ Generates negative ions!
- ✓ Blast of fresh air, no noise!
- ✓ Generates DC, not pulsed!
- ✓ 7.5kV DC negative, 400uA!

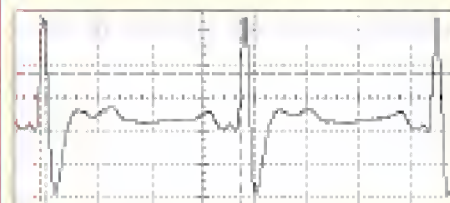
This nifty kit includes a pre-made high voltage ion generator potted for your protection, and probably the best one available for the price. It also includes a neat experiment called an "ion wind generator". This generator works great for pollution removal in small areas (Imagine after Grandpa gets done in the bathroom!), and moves the air through the filter simply by the force of ion repulsion! No fan blades, no noise, just swiftly moving, charged air.

Learn how modern spacecraft use ions to accelerate through space. Generate negative ions for health and healing! Includes ion power supply, 7 ion wind tubes, and mounting hardware for the ion wind generator.

IG7 Ion Generator Kit \$64.95
AC125 110VAC Power Supply \$9.95

Electrocardiogram Heart Monitor

- ✓ Visible & audible display of your heart rhythm
- ✓ Re-usable sensors included!
- ✓ Monitor output for your scope
- ✓ Simple & safe 9V battery operation



Enjoy learning about the inner workings of the heart while at the same time covering the stage-by-stage electronic circuit theory used in the kit to monitor it.

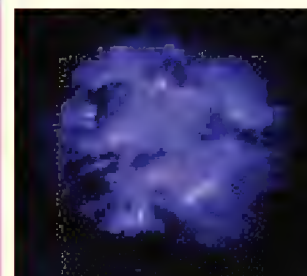


The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading every time! Multiple "beat" indicators include a bright front panel LED that flashes with each heart beat, an adjustable audio output to hear the beat, and of course, the monitor output to view on a scope, just like in the ER! Operates on a standard (and safe) 9VDC battery. Includes matching case for a great finished look. The ECG1 has become one of our most popular kits with hundreds and hundreds of customers wanting to get "Heart Smart"!

ECG1C Electrocardiogram Heart Monitor Kit With Case \$44.95
ECG1WT Factory Assembled & Tested ECG1 \$89.95
ECGP10 Replacement Reusable Probe Patches, 10 Pack \$7.95

Plasma Generator

- ✓ Generates 2" sparks to a handheld screwdriver!
- ✓ Light fluorescent tubes without wires!
- ✓ Build your own plasma balls!
- ✓ Generate up to 25kV @ 20KHz from a solid state circuit!



This new kit was conceived by one of our engineers who likes to play with things that can generate large, loud sparks, and other frightening devices. The result... the PG13 Plasma Generator designed to provide a startling display of high voltage!



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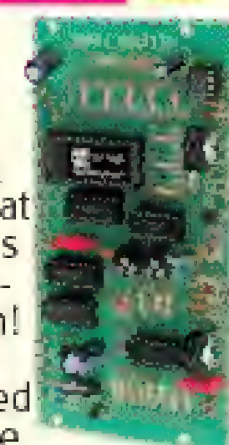
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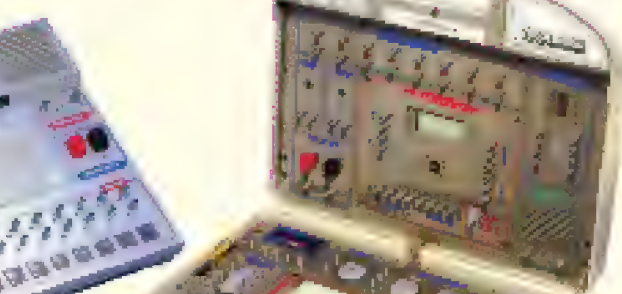
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High Stepping Automatic Coil Winder

An Intro to Precision Positioning

This Month's Projects

Coil Winder 40
AD/DA Converter . . 48
Spoke Signals 52



The Fuzzball Rating System

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You'll also find information included in each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

Have you ever thought of a project where you needed to position an object with great precision? Maybe you wanted to build a precision milling machine or maybe a computer plotter. My introduction to precision positioning came about from a need to wind wire coils for solenoids. Coils are used for all kinds of electrical applications – from solenoids for electromechanical actuators to coils for electric motors.

My first coil winder (shown in Figure 1) was just a DC motor turning a coil form. It required a steady hand to lay down the wire on the coil. The winder really had no idea of how many windings were on the coil. What I wanted was an automatic coil winder that I could set up, walk away from, and when I came back, have a finished coil. Even if you do not need to wind coils, this project provides a good introduction to precision positioning using stepper motors under computer control.

The automatic coil winder in this article uses stepper motors to position the wire in increments of 0.000651 inch. The motors are controlled through a personal computer's (PC) parallel interface. The Visual Basic software automatically estimates the wire length and stops the winding process when the desired number of windings is reached. The coils are wound without any human interaction except

to mount the coil form and to remove the finished coil. The automatic winder is useful in winding a number of identical coils.

Stepper Motors

Stepper motors are well-equipped for this project where rotation and lateral motion 'have to be controlled with great precision. There are many stepper motor controllers available for doing computer numerical control (CNC) machining; however, for this project, I decided to build a simplified stepper motor controller from scratch. I decided to use a PC as the "brains" of the controller and to use the PC parallel port to carry the control signals. Visual Basic (VB) was the language used to program the PC.

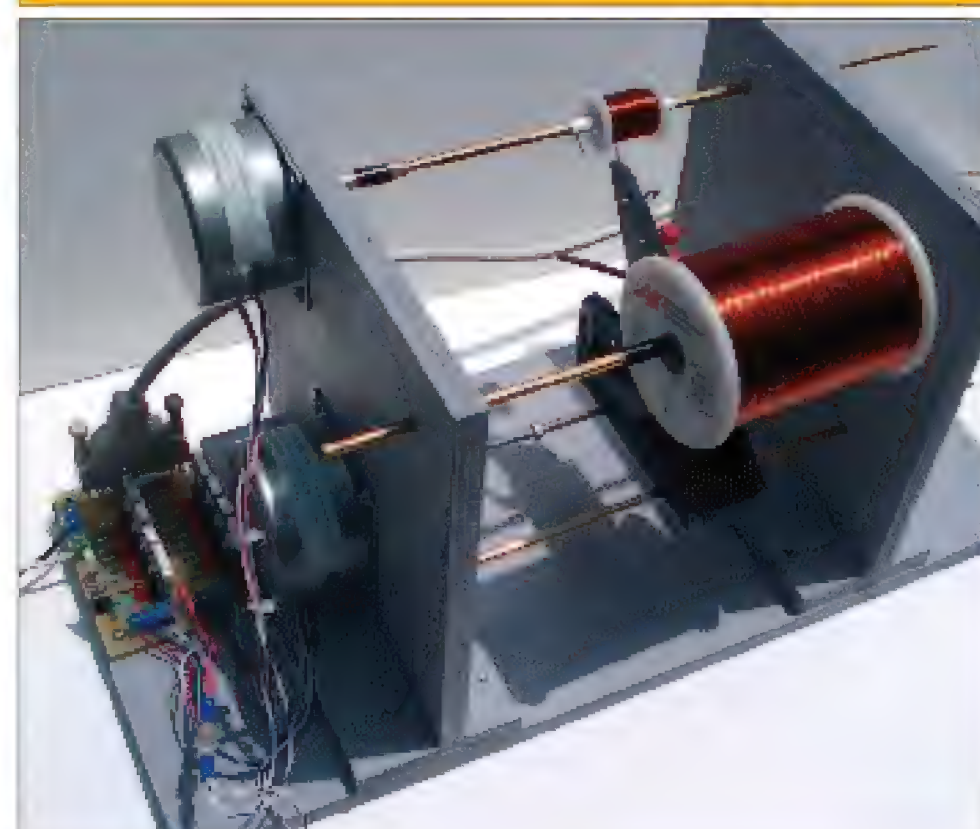
A unipolar stepper motor has two center tapped coils. A unipolar motor has five, six, or eight leads. The motor I chose has six leads. I identified the two center taps by measuring resistance with a suitable ohmmeter. The resistance from a terminal to the center tap is half the resistance of the two terminals of a coil. With the center taps identified as BLUE&WHITE and BLACK&WHITE, the remaining wires must be the coil terminal leads.

For the motor I chose, each energizing of a coil should rotate the shaft 7.5 degrees.

Figure 1. First Attempt at Automatic COILWINDER.



Figure 2. Final Completed Automatic COILWINDER.



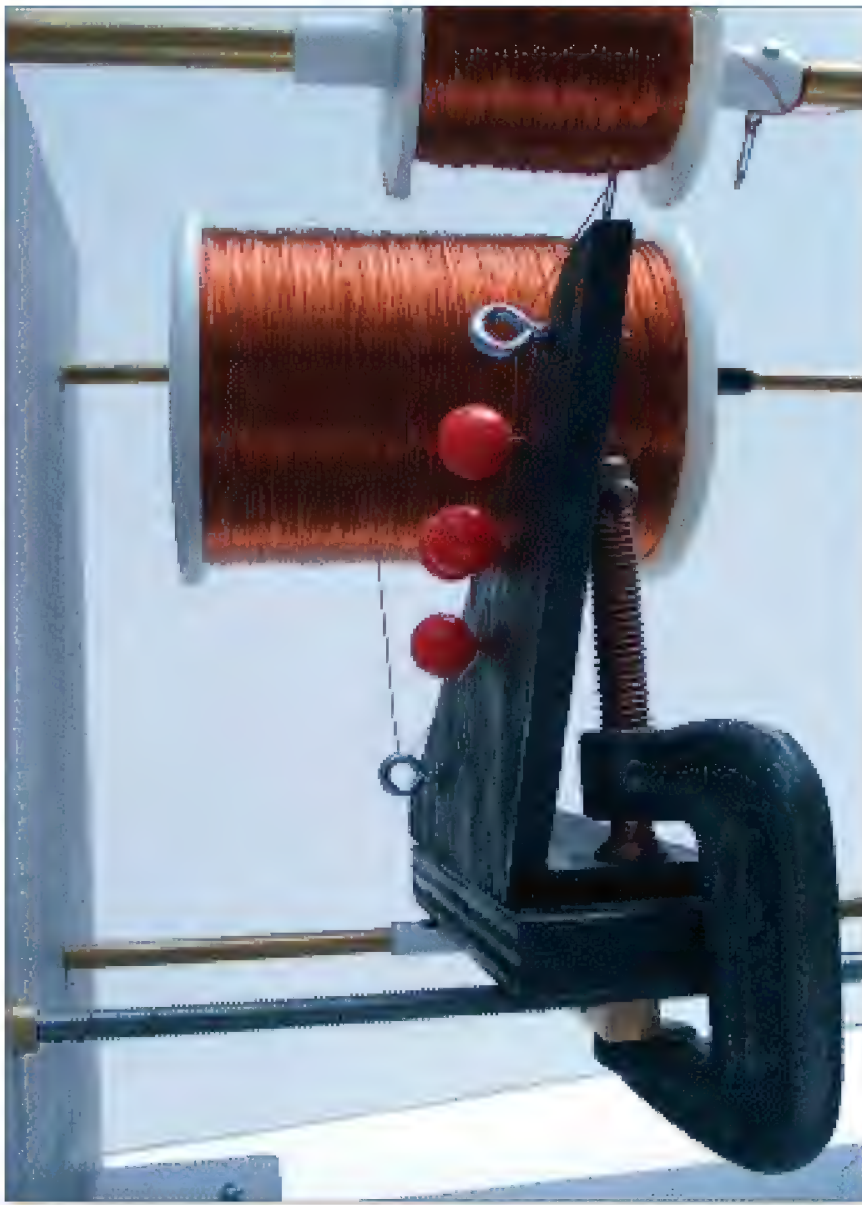


Figure 3. Finished Carriage.

Current flowing through a coil produces a magnet field which attracts a permanent magnet rotor which is connected to the shaft of the motor. By trial-and-error grounding of the terminal leads while five volts was applied to the two center taps, the proper sequence for clockwise rotation was found to be RED, BLACK, BLUE, and WHITE. Reversing the energizing order causes counter-clockwise rotation.

Two modes of motor operation are user selectable in the software. The default mode is WAVE, which means that each of the four motor coils is energized one at a time, in sequence. This mode draws minimum current. A second mode is HI-TORQUE. In this mode, two coils are energized at a time. This mode requires twice the current of WAVE mode; however, it does produce more torque in the motors.

I thought the COILWINDER would require two stepper motors. One motor controls the rotation of the coil and is called the winding motor. The winding motor turns the coil directly. The other motor controls the movement of a small carriage feeding the wire back and forth across the rotating coil form. This motor is called the carriage motor. The carriage motor drives a lead screw which translates the rotational motion of the motor to linear motion of the carriage.

Building the Hardware

The completed unit is shown in

JUNE 2005

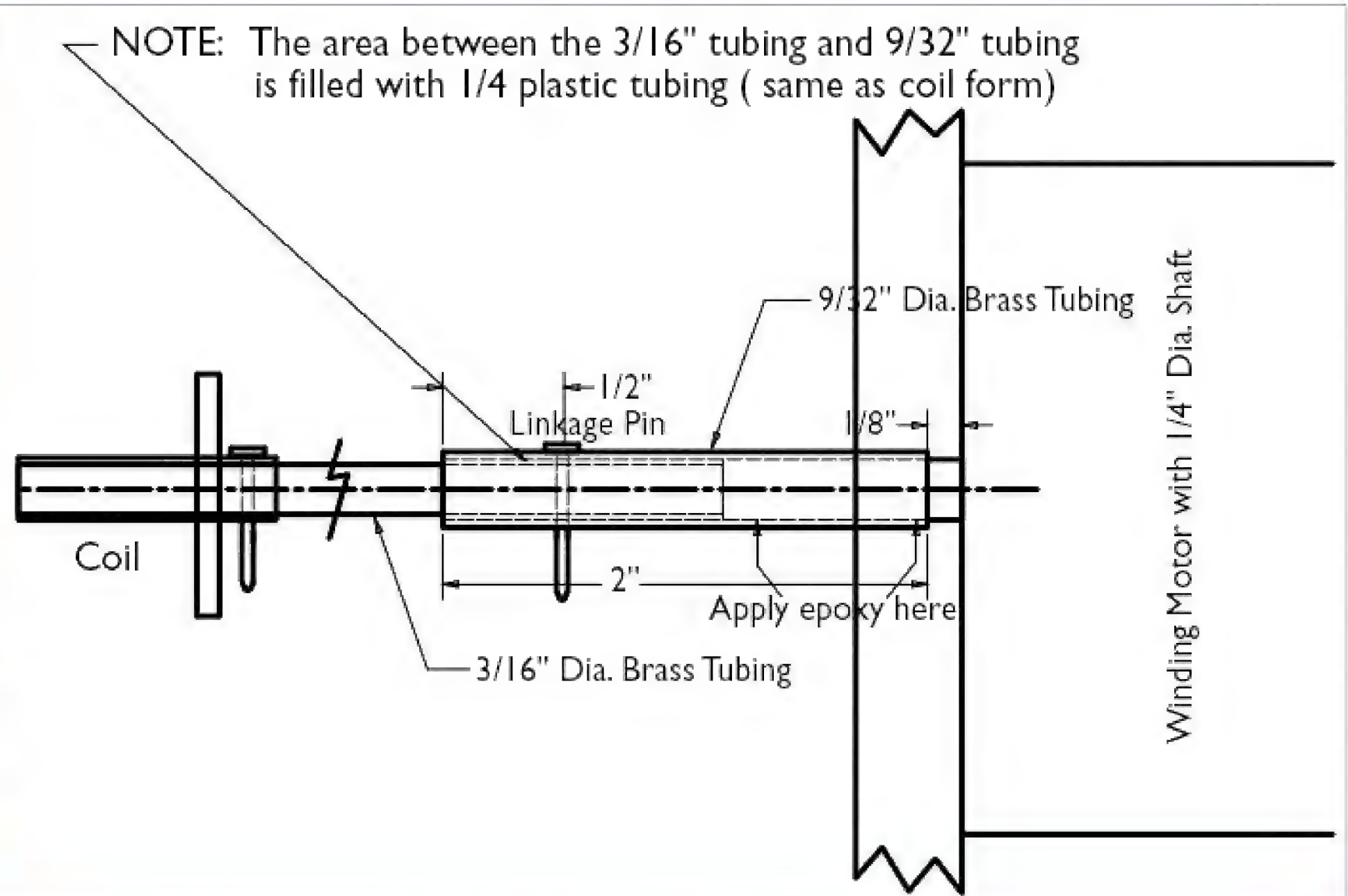


Figure 4. Detail of Shaft Coupling.

Figure 2. If you decide to use another stepper motor, just make the appropriate changes in the software for STEPANGLE and MAX_STEPS. If a threaded rod other than 32 TPI is used, change LEADSCREW_TPI appropriately. To drive the carriage, a "connector nut" for the lead-screw should be purchased or made. I made a connector nut from a one-inch piece of 9/32" square brass stock.

I drilled and tapped a #32 thread through the stock. Figure 3 shows that the carriage is made up of three pieces that are clamped together using a one-inch "C"

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The winder frame was built from 1/2" inch birch plywood. A detailed plan is shown in Figure 5. The assembly is straightforward, but the builder should be careful in drilling the holes for the motor shafts to ensure that they

in Figure 7. Figure 8 shows the pinout for the PC parallel port. After testing on the breadboard, the driver circuit was built on a 3 x 4 inch printed circuit board shown in Figure 9. Heatsinks were later added to the MOSFETs to keep them cool during extra long coil winds. The layout of the circuit board is available at www.nutsvolts.com

Writing programs to talk with the PC parallel port was

pretty easy in the old DOS days and in Win95/98, too. With the new era of NT-clone operating systems like WIN NT4, WIN2000, and WINXP, all this simplicity goes away. Trying to run a computer program accessing the parallel port on a WINXP computer will give a “PRIVILEGED INSTRUCTION EXCEPTION” error message. Being relatively secure operating systems, Windows NT/2000/XP assign some privileges and restrictions to different types of programs. It classifies all the programs into two categories: User

Figure 7. Circuit Diagram for Motor Driver.

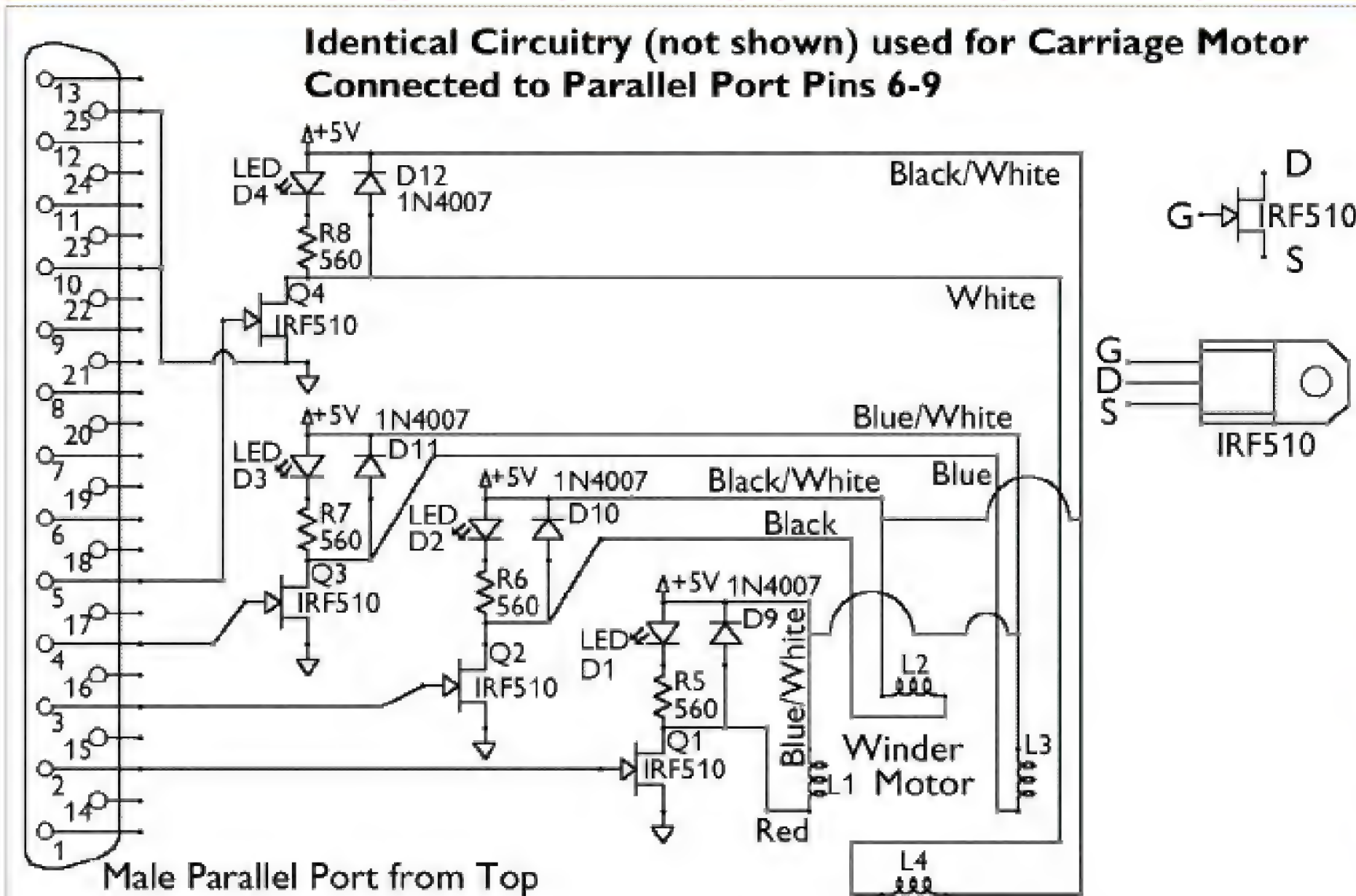
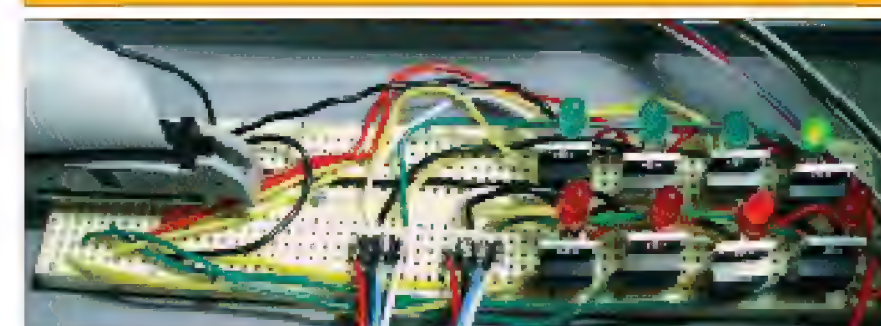


Figure 6. Completed Motor Driver Circuit.



mode and Kernel mode.

The programs that users generally write fall into the user mode category which does not allow direct access to the parallel port. The workaround for the above problem is to write a kernel mode driver capable of reading and writing data to the parallel port and let the user mode program communicate with the driver. Fortunately, someone else has already incorporated the driver into a dynamic link library called INPOUT32.DLL, and it is available for free at www.logix4u.net/inpout32.htm

The outstanding feature of INPOUT32.DLL is that it works with all the windows versions without any modification in the user code or the DLL itself. The DLL will check the operating system version when functions are called, and if the operating system is WIN9X, the DLL will use INP and OUT functions for reading/writing to the parallel port. On the other hand, if the operating system is WIN NT, 2000, or XP, it will install a kernel mode driver, HWINTERFACE.SYS, and talk to the parallel port through that driver. The user code will not be aware of the OS version on which it is running.

The statements that make the parallel port input (INP) and output (OUT) functions available to the VB program are:

```
Public Declare Function INP Lib "inpout32.dll" _
Alias "Inp32" (ByVal PORTADDRESS As Integer) As Integer
Public Declare Sub OUT Lib "inpout32.dll" _
Alias "Out32" (ByVal PORTADDRESS As Integer, ByVal VALUE As Integer)
```

The DECLARE statements simply tell VB that the programmer wants to use a function called OUT in his program that is known as Out32 in the INPOUT32.DLL located in the WINDOWS/SYSTEM directory. The OUT function takes an argument called PORTADDRESS which is the address of the parallel port and an argument called VALUE which is the data to be written to the parallel port. Program timing is controlled by a call to the WINDOWS application programming interface SLEEP function using another DECLARE statement.

Designing the Software

The software was written in Visual Basic for an IBM compatible PC and runs on all Windows operating systems. The actual winding of the coil begins when the BUILD COIL command button is pressed. For the actual winding of the coil software, I decided to use programming consisting of "state machines." The use of state machines for each function enables the software to be small yet respond quickly to real-world events giving great precision

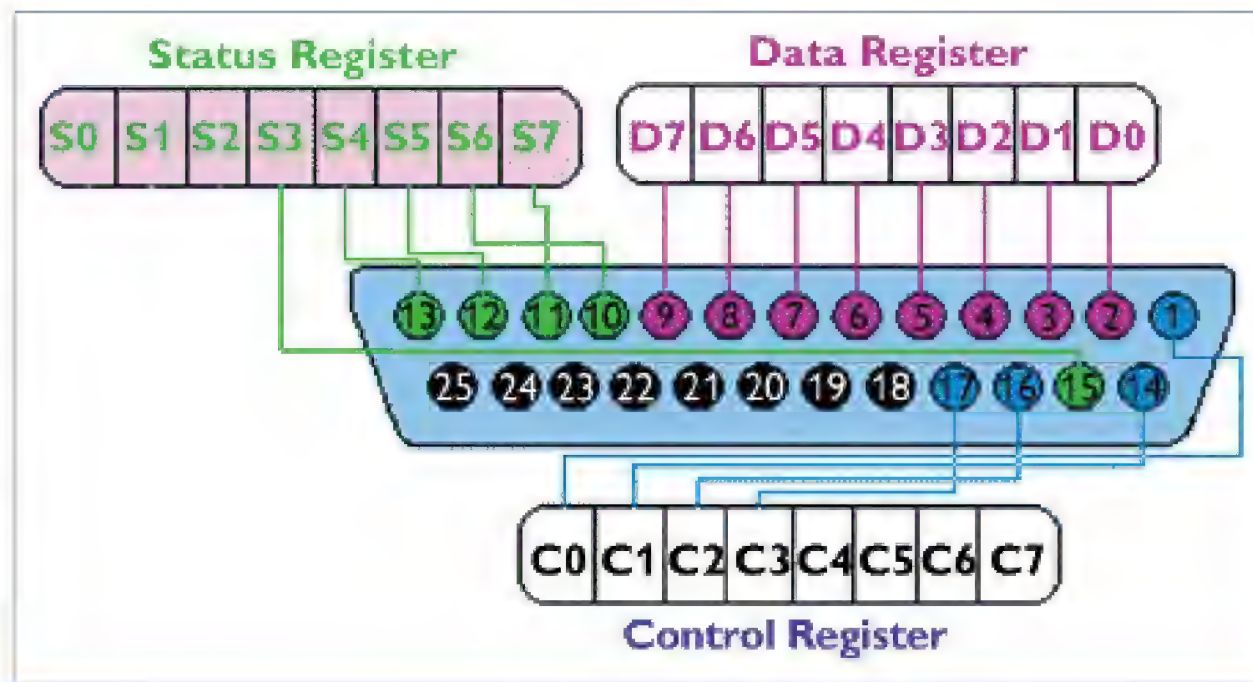


Figure 8. Parallel Port Pinout.

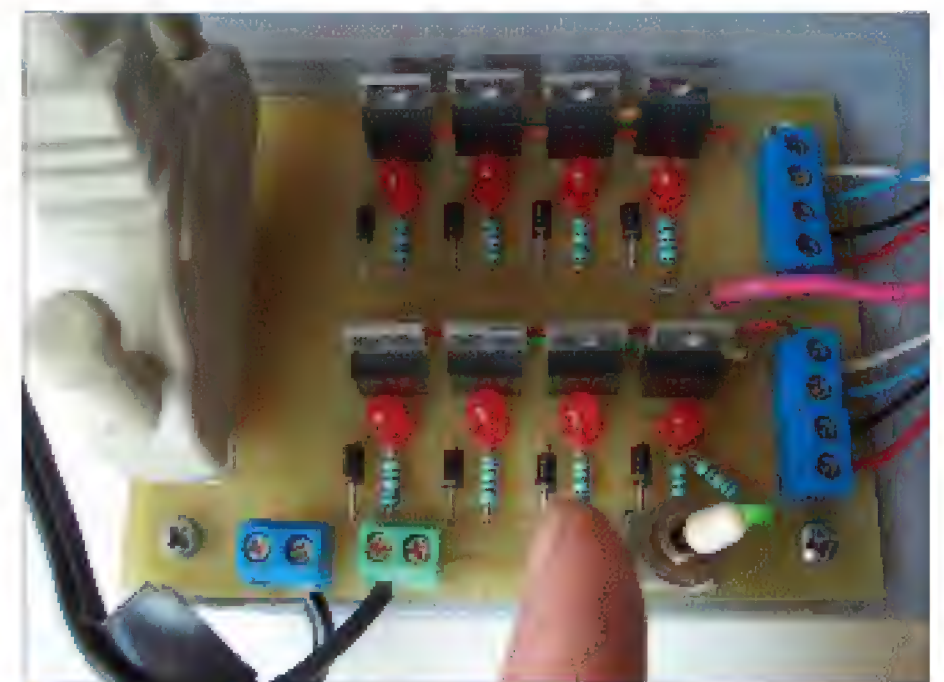


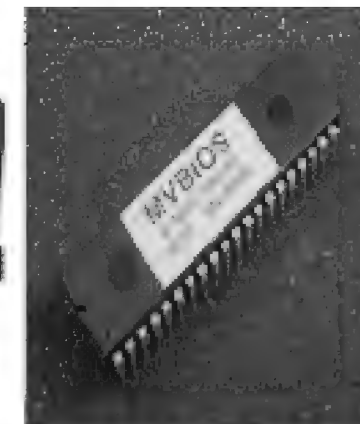
Figure 9. Printed Circuit Driver Board.

to the motor control. Each function consists of a number of states. Each individual state requires only a few instructions to complete before passing program control to the next function. This process of breaking functions up into small states is a superior formalism for modeling dynamic real-time behavior. The program consists of four functions. Each function has multiple states, as shown in Table 1.

The functions are called sequentially and the states repeat the same actions until the state is changed. For example, once the winder motor is put into FORWARD state, it will continue winding on each execution until some new condition changes the state. Each state is a separate

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Function	States				
PROCESS COMMANDS	GETSTART Allows user to manually position carriage to home position using L, R, P, and H keys	INITHOME Reads S or C key	STARTWIND Starts the winding process. Reads the P and T keys.		
CONTROL CARRIAGE	FORWARD Moves carriage motor one step forward	BACKWARD Moves carriage motor one step backward	PAUSE Output 0x00 to motors		
CONTROL WINDER	INITHOME Turns off winder and carriage motors	FORWARD Moves coil winder motor one revolution forward	PAUSE Calls CONTROL_CARRIAGE if in JOGMODE otherwise output 0x00 to motors		
DISPLAY RESULTS	INIT Requests user to position carriage to home using L, R, and H keys.	HOMESTATUS Displays state of move to home	START Requests user to enter S to start, C to continue, P to pause, or T to terminate	WINDSTATUS Displays wind count and carriage steps from home	NOUPDATE Leaves current display unchanged

TABLE 1. Program Functions and States.



Figure 10. Coil Form Pieces and Tools.

For the case of #32 magnet wire, we get:

Round(0.007951 inch / 0.000651 inches/thread) = Round(12.21) = Steps of carriage motor = 12. = STEPSPERTURN

CASE in the Visual Basic SELECT CASE statement. The CONTROL_CARRIAGE function is a sub-function of the CONTROL_WINDER function.

One of the key parameters in the program is INCH_PER_STEP. This parameter defines how far the carriage moves laterally on each step of the carriage motor. It is based on the steps per revolution of the carriage motor and the threads per inch of the carriage lead screw. For the motor and lead screw I chose, the STEPSPERREV=48 and the LEADSCREW_TPI=32. INCH_PER_STEP is calculated as follows:

INCH_PER_STEP = 1.000 / (LEADSCREW_TPI * STEPSPERREV) = 0.000651 inch per step

The main problem in the coil winder is determining how many revolutions the carriage motor should make per revolution of the winder motor. The value is calculated as follows:

One revolution of winder motor = WIRE_DIA = Steps of carriage motor * INCH_PER_STEP

Forty-eight steps are required for one revolution of the winder motor, therefore an output step to the carriage motor should occur every four winder steps=STEP_RATIO. If this is a non-integer value, it is rounded. In no case are more carriage steps output than STEPSPERTURN per winder revolution.

Since the coil winder is designed to wind coils with multiple layers of windings, a second problem was to determine when the carriage motor should reverse direction to lay down the next layer of wire. This was accomplished by using the SLIDESTEP counter and comparing it to the maximum slidesteps per layer, MAX_SLIDESTEPS. For example, for a one-inch coil using #32 magnet wire:

MAX_SLIDESTEPS = Int(WINDS_PER_LAYER *STEPSPERTURN) = 1512

Where WINDS_PER_LAYER = Round(COIL_LENGTH/ WIRE_DIA) = Round(125.77)=126

In theory, the calculations above should result in a per-

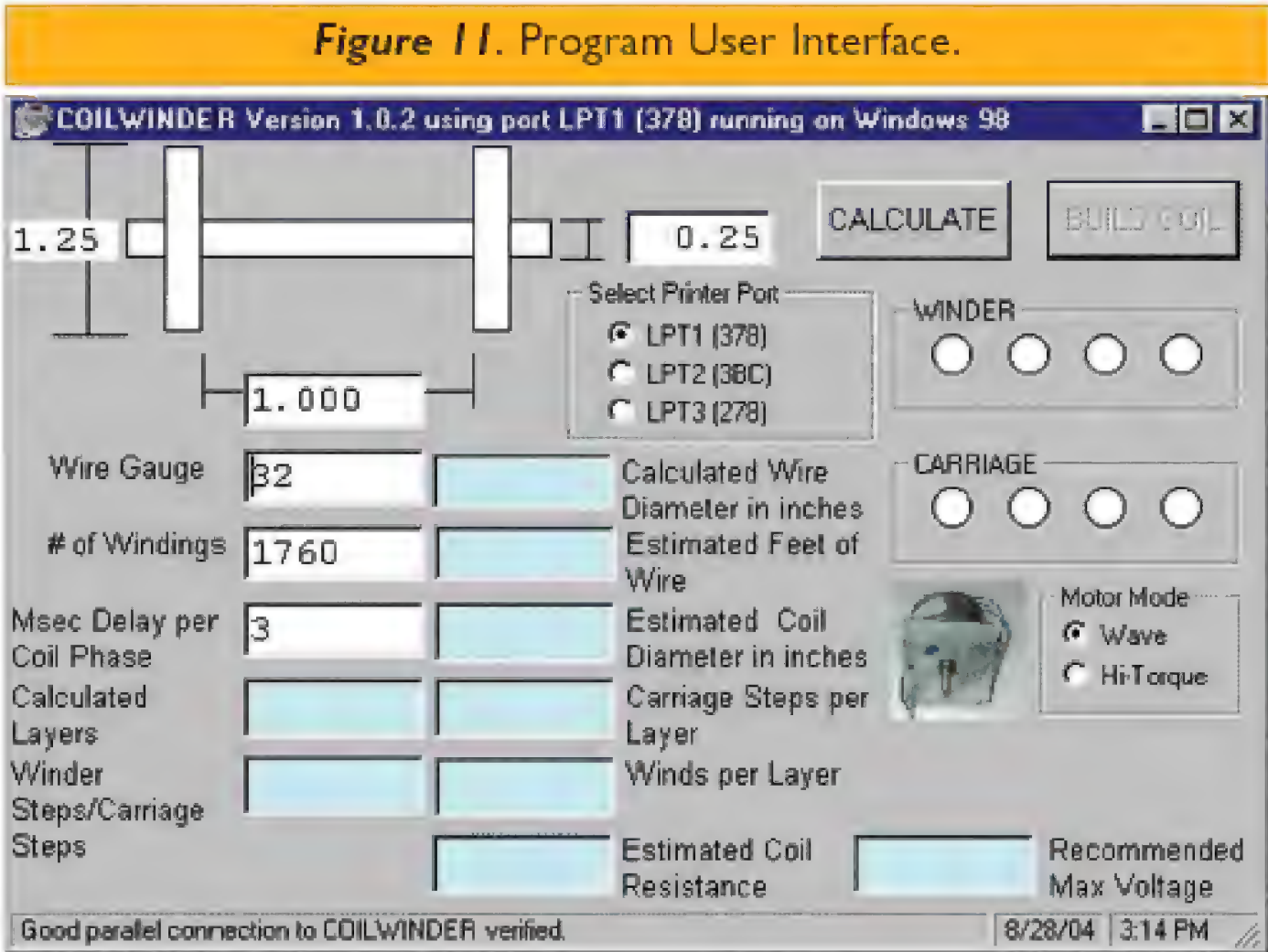


Figure 11. Program User Interface.

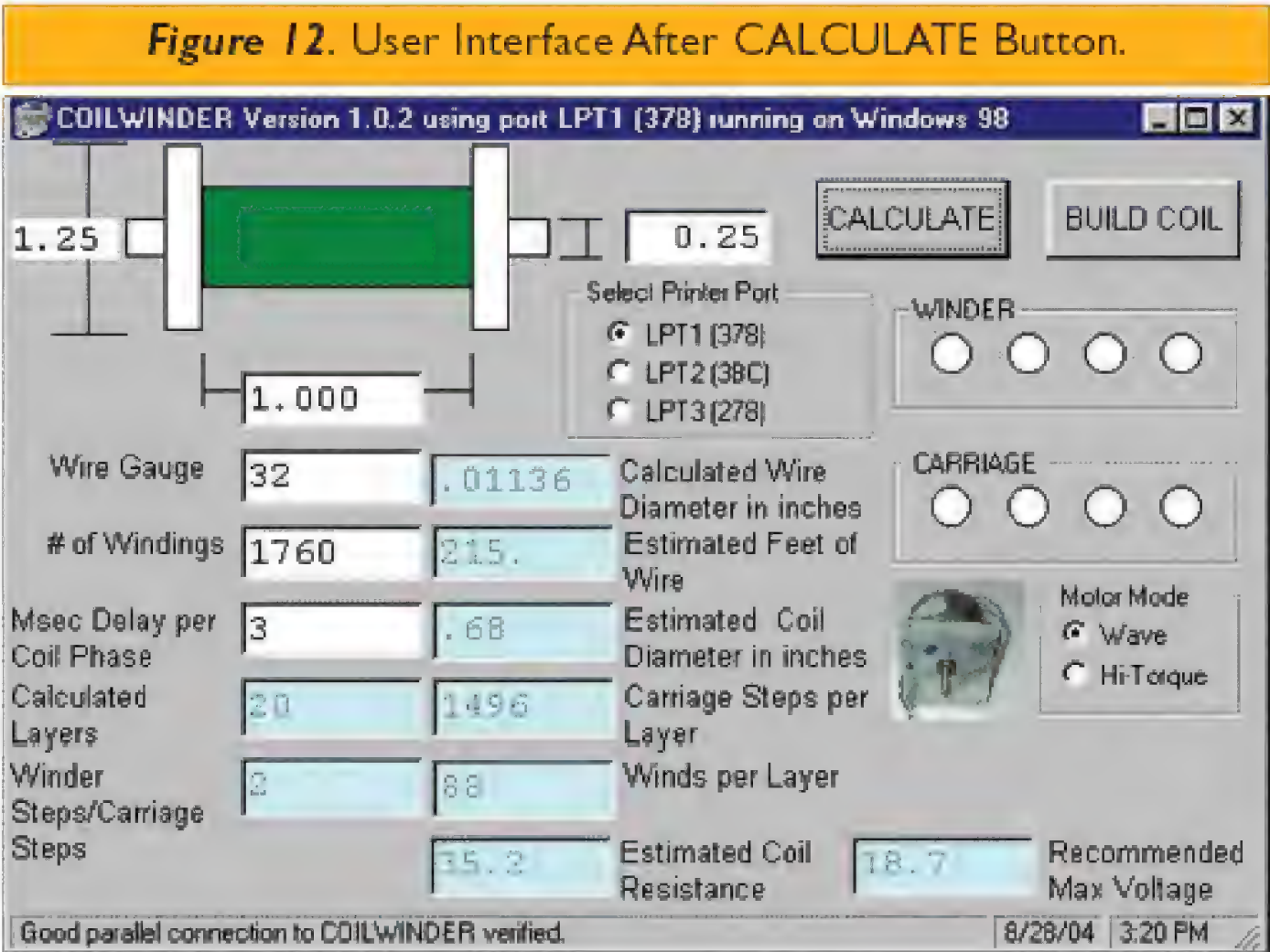


Figure 12. User Interface After CALCULATE Button.

High Stepping Coil Winder

fect coil. Unfortunately, the wire diameters in the code are based on wire gauges that do not include the insulation thickness. When I measured my #32 wire with insulation, I got a diameter of 0.01136 instead of the specified 0.0080. I modified the program to use the correct .01136 diameter for my #32 wire, but for other wire gauges, the user will have to modify the wire gauge/wire diameter lookup table after measuring their wire diameter with insulation. The VISUAL BASIC source code and installation package for the COILWINDER program are available from www.nutsvolts.com

Using the System

To wind a coil, first a coil form is needed. I built my forms from 1/4" styrene plastic tube and 0.06" thick sheet styrene, both available from your local hobby shop. I used a 1-1/4" hole cutter to cut out the round pieces of the coil spool. It also makes a nice 1/4" hole in the center for the coil tube. The spool end pieces are glued onto the plastic tubing with styrene plastic glue using an alignment tool fabricated from a thread spool. Small holes are drilled in the end piece for the wire feed and wire exit, and in the tube for the coil pin. The tools and pieces are shown in Figure 10.

The drive pin from the winder shaft is removed, freeing the winder shaft. The form is placed on the winder shaft

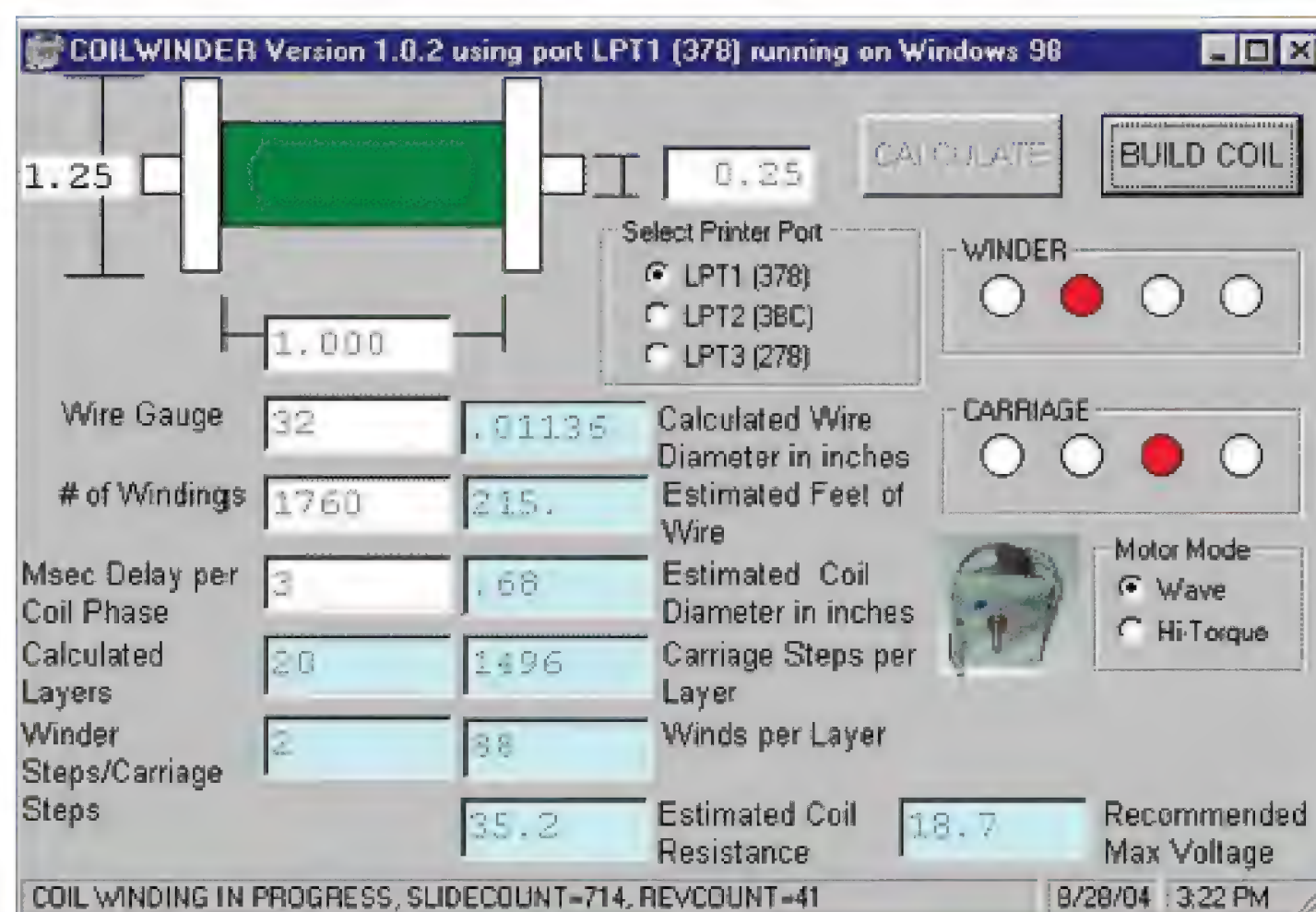


Figure 13. User Interface During Winding Process.

and secured from free rotation with the coil pin. The winder shaft is reattached to the motor with the driver pin. Wire is fed from the supply spool, through the tensioning pins, through the needle's eye, onto the coil form, and out the coil feed hole. We are now ready to wind!

When the program is started, it first checks to see if the COILWINDER is connected to the parallel port. The user



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Figure 14. Completed Coil.

interface at program startup is shown in Figure 11. The user can enter wire gauge, coil diameter, coil length, the number of coil windings, and the winding delay. The user next presses the CALCULATE command button and the program calculates the estimated feet of wire required, the number of winding layers, the wire diameter, the outer diameter of the coil, and the number of carriage steps per layer.

Sources and References

Source 1

Magnetic Gun Club

<http://mgc314.home.comcast.net/index.htm>

Source 2

Eddy Current Testing Information

www.ndted.org/EducationResources/CommunityCollege/EddyCurrents/cc_ec_index.htm

Source 3

Tesla coil design

www.noonco.com/tesla/

Source 4 — www.allelectronics.com

Source 5 — www.jameco.com

Next, the program calculates the estimated coil resistance and a recommended maximum voltage based on the resistance and the current limit of the wire. The program also calculates the ratio of winder steps to carriage steps using the equations above, as shown in Figure 12. The number of feet calculated is accurate to within about 10%. The program recalculates the number of windings based on complete wire layers. If you want the lead and exit wire to be on the same end of the coil, make sure the number of layers is even. For opposite ends, use an odd number of layers.

When the BUILD_COIL command button is pressed, the STATUSBAR first instructs the user to position the carriage to the “start winding” point by using the “L” and “R” keys. The “H” key is used to indicate that the carriage has reached home position. Next, the user is instructed to hit “S” to start winding the coil. When the “S” key is hit, the winding starts and the STATUSBAR continuously updates the carriage steps per layer and the number

of windings completed, as shown in Figure 13. The “T” key can be used to terminate the winding at any time. When the winding is complete, the motors stop and the “L” and “R” keys are activated for initializing the next coil. During the winding process, the “P” key can be used to pause the winding and the “C” key can be used to continue.

In order to maximize the speed of the winding, whenever a motor is started, there is a 28-step motor startup sequence where the first step takes ~221 times the input millisecond delay. The delay is reduced exponentially until the 28th step takes the input millisecond delay. This was done to allow the motors to start up gradually to prevent motor “chatter” that occurs when stepper motors are cycled at their maximum rate from a dead stop. If chatter still occurs as the motors get up to speed, then the input millisecond delay should be increased.

Summing it Up

An interesting project of an automatic coil winder has been constructed for less than \$35.00. The unit can automatically wind high quality coils as shown in Figure 14. It took approximately 24 minutes to wind the 224 foot coil of # 32 magnet wire consisting of 1,800 windings, using a delay of three milliseconds. This project provides an introduction to Visual Basic, the PC parallel port, and stepper motors. **NV**

Parts List and Suppliers

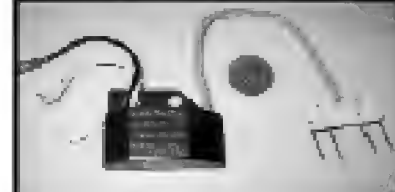
Quantity	Part ID	Description	Source/Part #	Cost	Total Cost
2	M1, M2	5 volt, 1.38 amp, 48 step/rev, 0.25" diameter x 1" shaft, Stepper motor	Source 6 SMT-62	\$3.75	\$7.50
1	T1	#10 x 32 threads per inch x 12" rod and connector nut	Source 8	\$.96	\$.96
3	BS1-3	3/16" x 12" diameter brass tubing	Source 9	\$.75	\$2.25
1	BL1	9/32" x 12" diameter brass tubing	Source 9	\$1.19	\$1.19
1	PT1	1/4" x 12" styrene plastic tubing	Source 9	\$.75	\$.75
1	PS1	.06" x 2" x 6" styrene plastic sheet	Source 9	\$.75	\$.75
8	Q1-Q8	N channel, 100V, 5.6 amp IRF510 MOSFET (#209234CL)	Source 7 209234CL	\$.46	\$3.68
1	DB1	DB-25 connector (male)	Source 7 15122CL	\$.65	\$.65
8	R1-R9	620 ohm, 1/4 watt resistor	Source 7 31376CL	\$.01	\$.09
8	D9-D16	1N4007 diode	Source 7 36011CL	\$.04	\$.32
8	D1-D8, D17	LEDs	Source 7 34606CL	\$.15	\$1.35
1	P1	5 volt/4 amp DC power supply	Source 6 15347-PS	\$10.95	\$10.95
1	SW1	SPST sub-miniature power switch	Source 7 72160CL	\$1.29	\$1.29
1	W1	1/2" x 18" x 8" birch plywood	Source 8		
2	W2-3	1/2" x 8" x 8" birch plywood	Source 8		
2	W3-4	1/2" x 3" x 8" birch plywood	Source 8		
1	W6	1/2" x 4" x 1.25" birch plywood (carriage base)	Source 8		
1	W7	3/16" x 4" x 8" birch plywood (wire guide)	Source 8		
1	BB1	Printed Circuit Board Materials or breadboard	Source 7		

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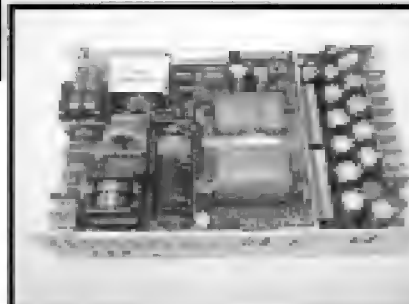
Ion Generator



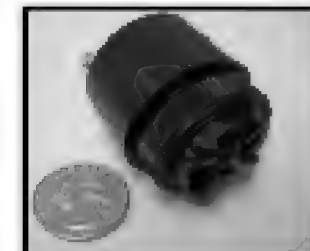
Its super easy to build your own Ion Breeze air purifier! New module, 120 VAC in, 7.5KV out! Surplus from air cleaner maker who sold them for \$200! 0128873R\$7.95

Power Supply

Nice new switching supply. 100 240VAC IN, OUT: +5V@20A, +12V@6A, 12V@1A, 5V@1A. Screw terminals, size 6.2"x4"x1.4" 0133539R\$14.95



Piezoelectric Alarm



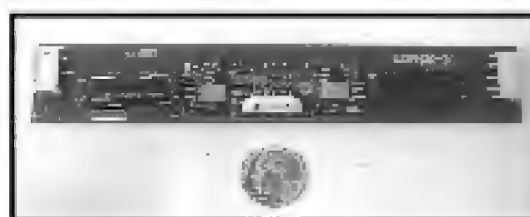
WOW, is this thing LOUD! Runs on 2 12 VDC and draws mere milliamps, 103db output! Rotating bezel allow easy volume control too! 1.25" dia and 1.5" long. Google for specs: Bell Audiolarm XC V09 212 S 0132165R\$4.95

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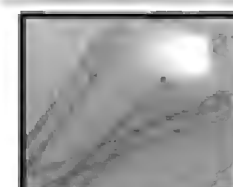
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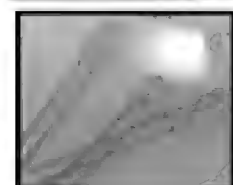
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Get a load of this incredible price on super bright WHITE LEDs! Minimum 4,500 mcd AMAZINGLY BRIGHT! 3.4 volt 20 ma. We bought out the entire factory! Stock up now at these incredible prices! All factory prime material!

0135037R 50 pcs \$19.95
0135037 500 pcs \$99.95

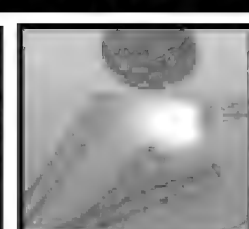
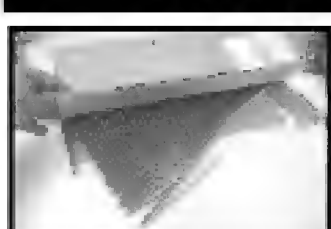
Windsor's Blue LED Special



Holy Smokes! Can you believe the price on this BLUE LEDs? First quality from our factory buyout. Big and bright! These normally sell for \$1.50 each and that's in big quantities! We're crazy to sell 'em so cheap!!

0131297R 50pcs \$19.95
0131297 500pcs \$99.95

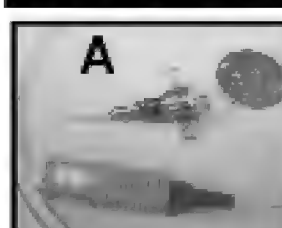
LED BLOWOUT !!!



Here's a deal that just will not last long Windsor's LED Blowout! Super high quality, factory prime bright LEDs. Ideal for all those projects that you've wanted to build, but just didn't have the quantity of LEDs needed. You will not find pricing like this ever again we bought out two factory inventories! Here's the scoop: Big bag o leds have 500 pcs and are all RED jumbo 5 mm size with crystal clear bulbs. You pick the luminous intensity, bear in mind that the 2500 mcd high bright units are flashlight intense! Big buyers will love the 2,000 LED boxes! These LEDs are the smaller T 1 size with full leads, available in Red or Green. Imagine 2,000 Leds for less than a penny each!

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Item A: 0128526R Item B: 0128536R



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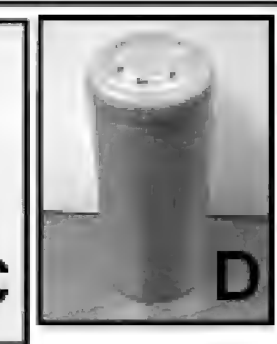
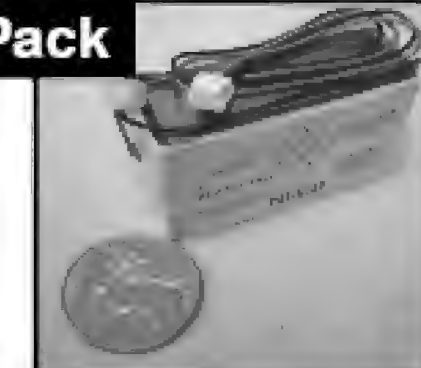
Rechargeable Battery Blowout!

Big box of 50 brand new AA but ton top NiCads. Fit anywhere an AA battery does. 1.25V 800mah. Best price in the USA! 0128870R \$19.95



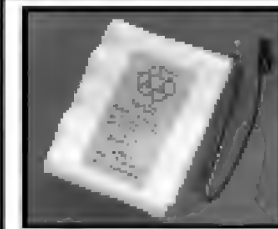
Nicad Battery Pack

Brand new high power density rechargeable battery pack. 6 volts, 650 maHr. Space saving rectangular shape approx 2x1x0.75" 6" wire leads. 0132161R\$4.95



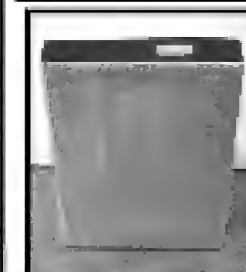
Popular Nicad batteries, 1.25V All brand new. Battery in picture A has no sleeve.

A: AAA 400mah 0125339R 2 for \$1.00
B: AAA 250 mah 0133089R 5 for \$3.00
C: AA 700mah 0132163R 5 for \$3.00
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USB 16-bit AD/DA Converter

Build a USB Soundcard for your Desk PC or Laptop

I have always been fascinated by computers interfacing to the real world. During the last years, all kinds of interfaces have popped up: serial (RS-232, RS-485, ...), parallel, different standards, several speeds, USB 1.0, 1.1, and 2.0, SATA, ... USB or 'Universal Serial Bus' gave an answer to some of the problems encountered like speed issues and bi-directional communication (ever tried to input data on a printer port?).

This project describes the construction of a mini USB soundcard, which can be used to add a soundcard to your desktop PC or portable computer. Voice or sound recording is possible simultaneously, as well as hooking up external sound speakers for quality music playing or gaming. A very compact design (2" by 3") and low cost makes this an ideal project for the practical electronics hobbyist/professional. Just take this circuit, hook it up to a free USB port on a PC or a portable (without opening the case), attach a headphone, and start listening to your favorite CDs. It's as simple as that.

No bigger than your credit cards or wallet, it is self-powered from the USB bus. For the audio lover, it excels in audio performance for a low price, too. You can use this circuit as an audio player, as well as capturing sounds, using a microphone or an audio source. You can record voice messages and send these 16-bit sound recordings via email to friends and relatives. Ever thought of organizing a karaoke evening? Big fun!

You can easily build this project yourself or a high-quality circuit board, as well as the component set, is available from the author (see references). A completely built and tested module is available, as well.

Chip Overview: PCM2900

The heart of the circuit consists of a single chip USB codec from Texas Instruments, the PCM2900. Being USB 1.1 compliant (full speed protocol converter), the chip acts as a bi-directional USB to analog audio converter, including 16-bit AD/DA converters. There is no need for programming the device or booting parameters from an E2PROM, which makes the design efficient and compact. On-chip voltage regulators make up the necessary voltages for all internal cores, sourced from the 5V USB bus power (VBUS pin). External powering is not necessary. The on-chip analog PLLs enable independent playback and record sampling rates with low clock jitters. Due to its compact 28-pin SSOP package, the chip excels in density, looking at all features that are on-board. Complete details on this chip can be found in References (1) and (4).

Block Diagram Description

A 12-MHz crystal provides the reference clock source required by the on-chip clock generation circuitry. Internal analog PLLs are used to generate low-jitter AD/DA clocks for handling the stereo audio signals. After termination of the USB bus by the USB engine, audio samples are interfaced to the on-board 16-bit AD/DA converters. A red LED gives an indication on the state of the USB data bus. When data on the USB is in a constant idle state, the LED illuminates.

The stereo audio interfaces are 3.5 mm stereo mini jacks for connection to a microphone, powered speakers, or audio test equipment. The analog output drives a sec-

Figure 1. Block diagram AD/DA converter.

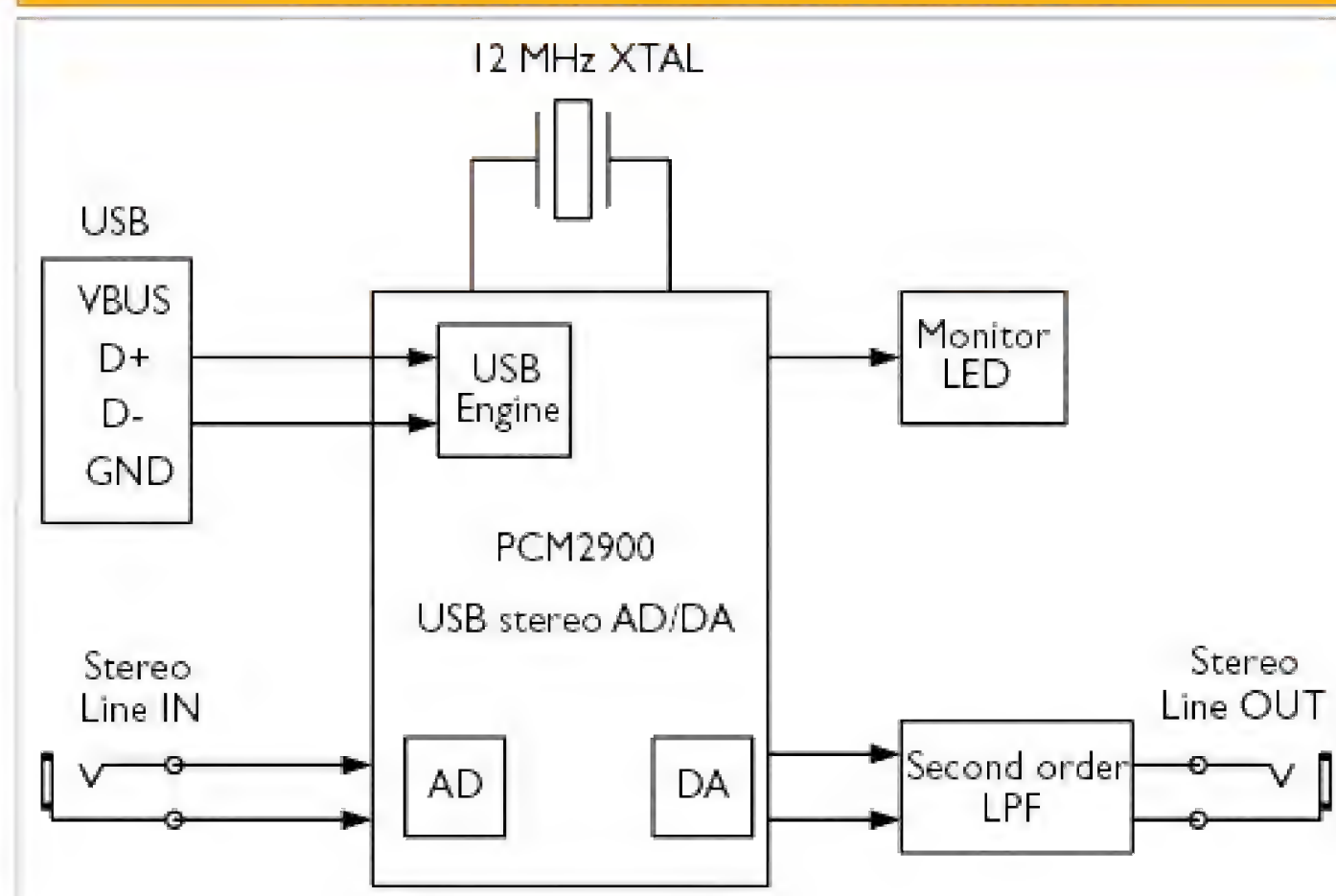
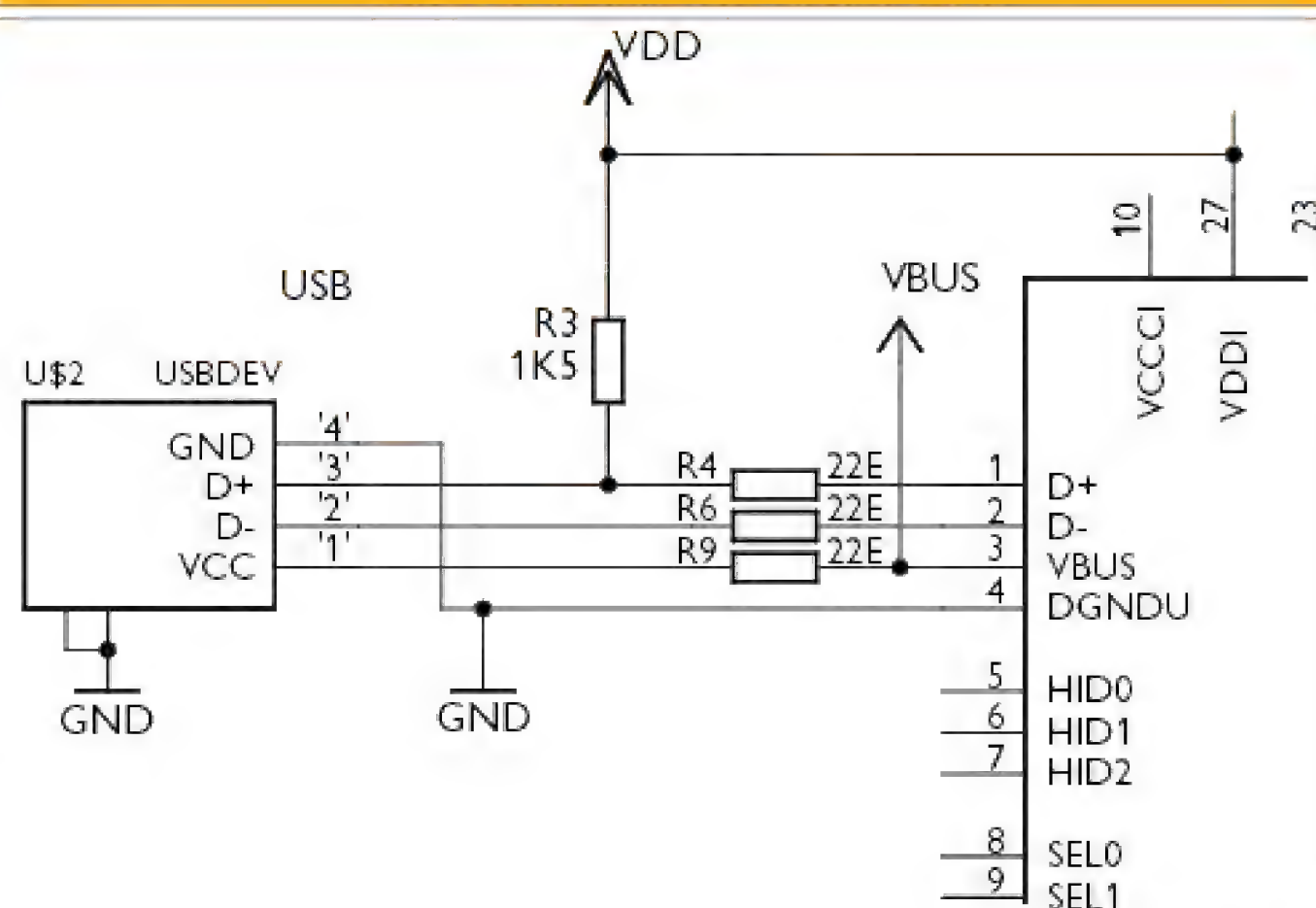


Figure 2. USB interface circuit.



ond-order low-pass filter, with a cut-off frequency around 20 kHz. This eliminates all unwanted harmonic residues from the DA conversion process.

Circuit Details

The schematic diagram is built around the TI PCM2900 and reflects a minimum of active components. The schematic can be subdivided into five areas: the USB interface, power conversion, the stereo input stage, the USB codec, and the stereo output stage (including filtering). Again, the AD/DA converter is bus-powered, meaning that the power supply is sourced from the +5V pin from the USB bus. Let's take a look at each sub block and go into detail.

USB Interface

The PCM2900 directly connects to the USB plug, where D+, D- is the digital USB data and VBUS is the bus sourced supply. R3 is a pull-up to VDD, being 3V3, in order to define the USB data connections at transient. The USB ground pin is connected to the single ground plane on the board. Series resistors of 22 ohms suppress overshoot/undershoot on the USB bus.

Power Conversion

To achieve the highest quality with the AD-conversion process, the manufacturer of the chip highly recommends to power the PCM2900 with an external voltage regulator, which is the LE33CZ (comes in a TO-92 housing). This causes the harmonic distortion of the AD converter to be lower than 10 dB, compared to the situation where the internal voltage regulator is used. C1, C2, and C3 serve as a standard low-frequency filtering of the power rails. VBUS is the +5V input.

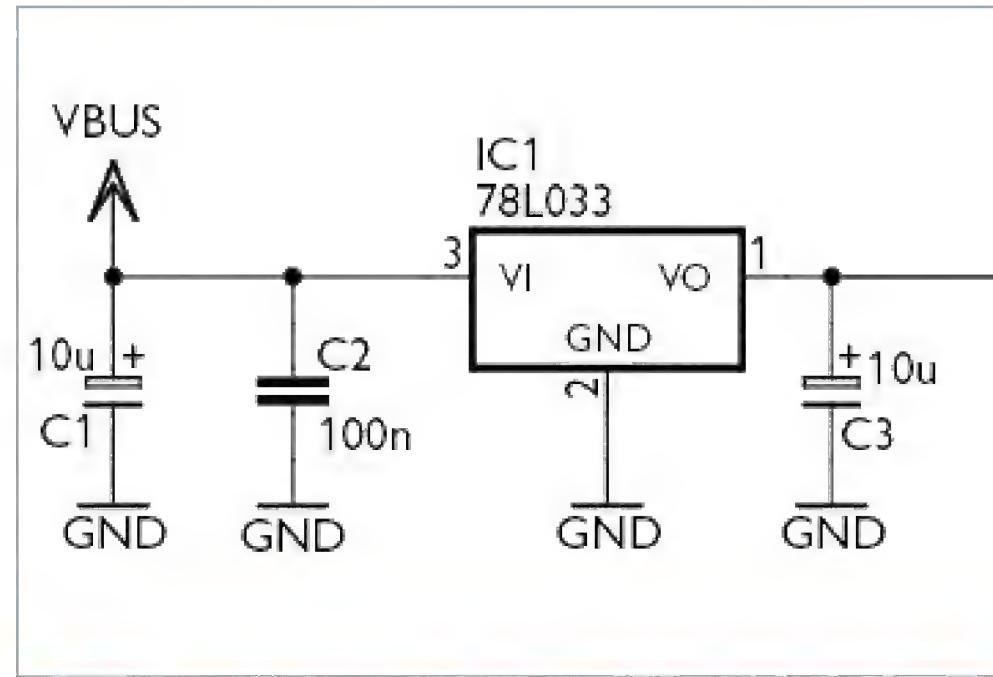


Figure 3. Power conversion circuit.

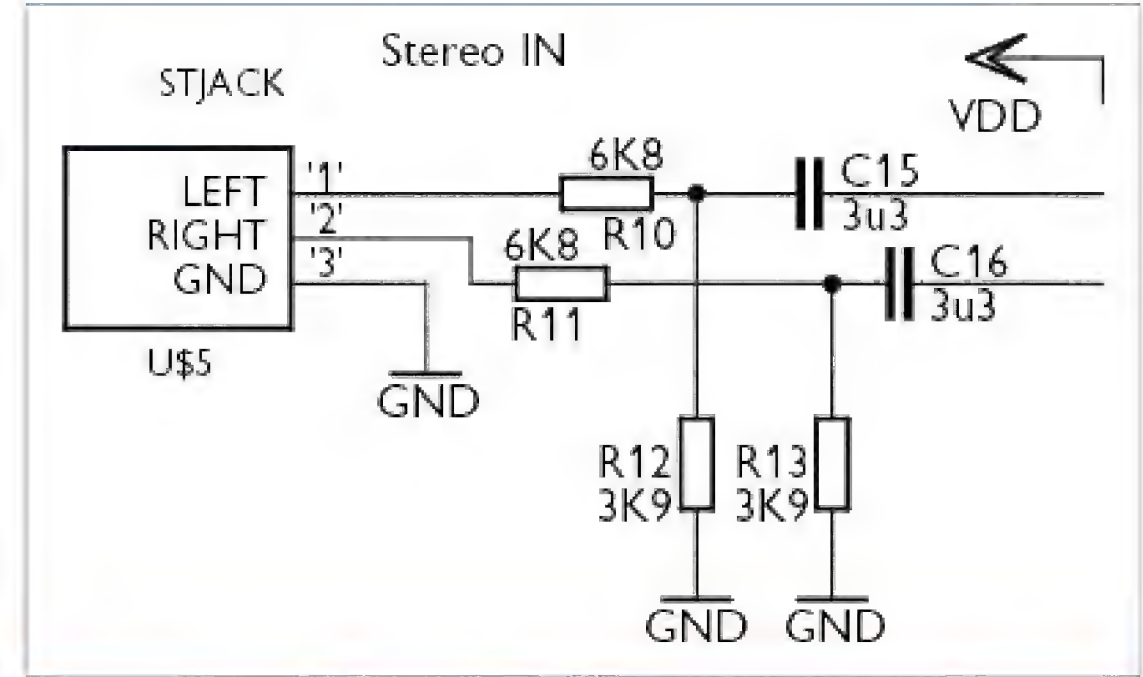


Figure 4. Analog stereo input circuit.

Stereo Input Stage

The analog input section of the PCM2900 chip has a fixed input sensitivity. After installation of the AD USB hardware, no regulation (in the driver) on the AD converter can be found as such. The input window of the PCM2900 is dimensioned at $0.6 \times V_{CCI}$, with V_{CCI} 3.3V equal to 1.98V peak-to-peak. The resistive divider R10 and R12 (or R11 and R13) is set at $3k9 / (3k9 + 6k8)$ or 0.36, which gives a maximum window at the input of the stereo jack of 5.5V peak-to-peak. C15 and C16 are DC decouplers and the choice of MKT types of capacitors is for quality reasons. The input impedance of the section is 10.7 K ohms.

Measurement Results

(Measured at 0dB, 44.1 kHz unless otherwise mentioned)

Input signal	USB audio data
Nominal output signal	62% VCC (1,096 Veff @ 5V)
Frequency range (output loaded with 10K)	5 Hz ... Fs/2 (Fs = sampling frequency)
Amplitude @ 20 kHz	-0,25dB
BW analog filter	30 kHz (MFB)
Output impedance	100 ohm
Signal-to-noise ratio	> 101 dBA
THD+N (1 kHz, B = 80 kHz)	< 0,0035 %
THD+N (20 kHz, B = 80 kHz)	< 0,025 %
IMD	< 0,006 %
Channel separation	> 116 dB
Stopband attenuation digital filter	> 82 dB
Current consumption	< 60 mA

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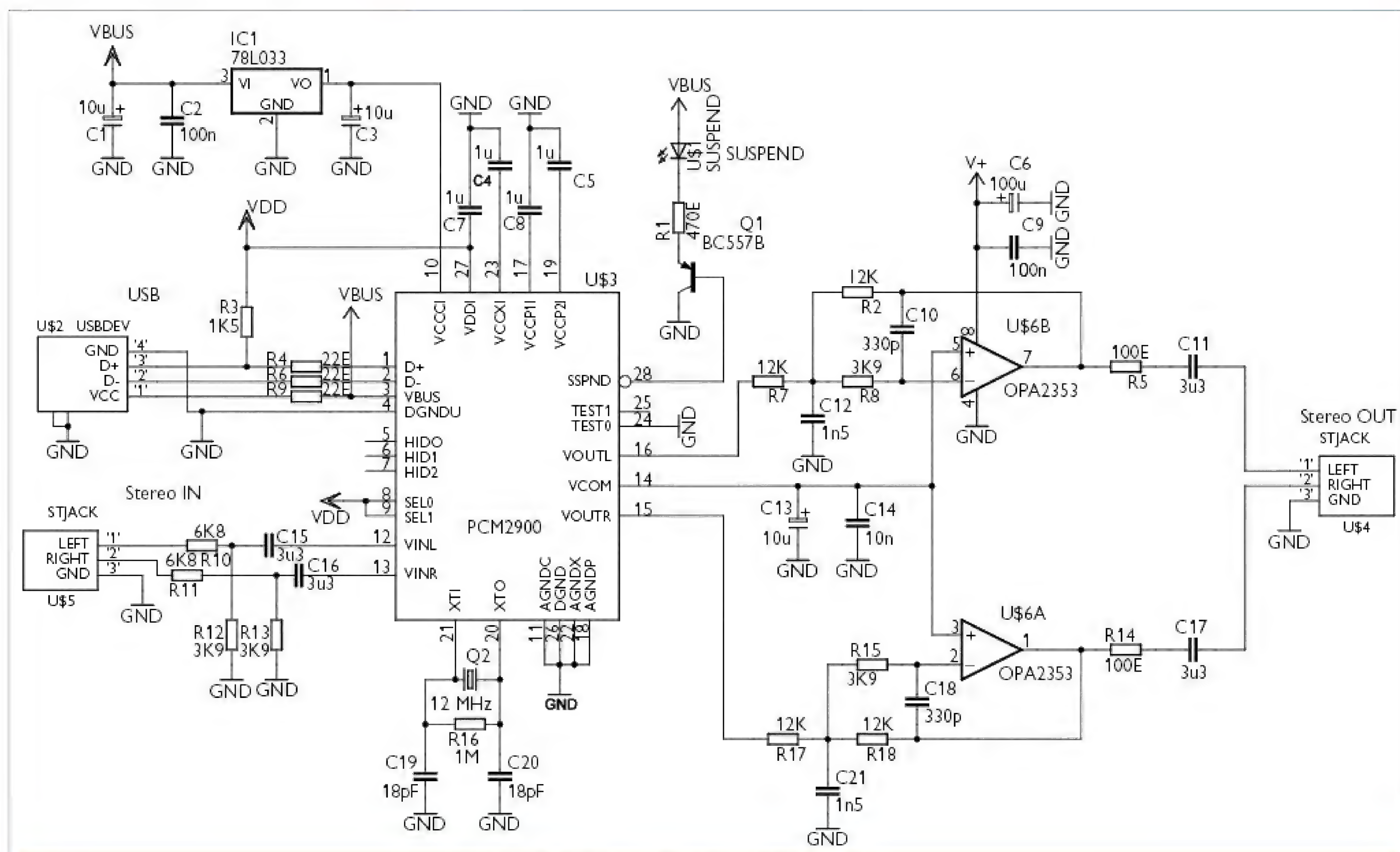


Figure 5. Complete schematic diagram.

USB Codec

The USB codec is a single chip PCM2900, very compact in a SSOP 28-pin housing. The SSPND signal indi-

cates valid audio USB data. An external clock of 12 MHz is generated from an external XTAL, with two ceramic capacitors for loading.

Parts List

Parts	Quantity	Value	Device
C1, C3, C13	3	10u	ELC-2,5L
C10, C18	2	330p	MKT or polyprop
C11, C15, C16, C17	4	3u3	MKT or polyprop
C12, C21	2	1n5	MKT or polyprop
C14	1	10n	Multipurpose decoupl
C19, C20	2	18pF	Ceramic
C2, C9	2	100n	Multipurpose decoupl
C4, C5, C7, C8	4	1u	C-EUC1206K
C6	1	100u	ELC-2,5L
IC1	1	78L033	LDO, TO92 package
Q1	1	BC557B	TO-92-EBC
Q2	1	12 MHz	CRYTALHC49S
R1	1	470E	RES 0.25W
R10, R11	2	6K8	RES 0.25W
R16	1	1M	RES 0.25W
R2, R7, R17, R18	4	12K	RES 0.25W
R3	1	1K5	RES 0.25W
R4, R6, R9	3	22E	RES 0.25W
R5, R14	2	100E	RES 0.25W
R8, R12, R13, R15	4	3K9	RES 0.25W
U\$1	1	LED	LED3MM
U\$2	1	USBDEV	USB B angled/board
U\$3	1	PCM2900	SSOP28
U\$4, U\$5	2	STJACK	Stereo Jack
U\$6	1	OPA2353	SO08

Stereo Output Stage

The PCM2900's internal DAC has a cut-off frequency of 250 kHz. As it is a delta-sigma DAC type, noise shaping causes a lot of noise above 20 kHz. For the analog output section, a third order, low pass filter is chosen (Butterworth type, f_c at 28 kHz). The active component in this filter is also from Texas Instruments – the OPA2353 (SMD type SO-8). This opamp is a high speed, low noise, low distortion, and (most important) rail-to-rail input and output. All capacitors are MKT, for quality of the signal processing, and extra filtering is put on the power supply of the opamp, to reduce any HF influence.

Construction

The double-layer board layout holds the USB connector on one side and the stereo mini jacks for both input and output on the opposite side. The SSOP package of the PCM2900 chip forces the routing of the board to 10 mil. Start the construction of the board by soldering the PCM chip, using a fine-pitch solder iron (18-20 Watts). Soldering flux is helpful, as well. Position U3 and first solder two opposite pins. Re-check the pin positioning relative to the pads.

Soldering the SSOP package pins sometimes causes joints between pins, which can be removed by de-soldering litze. After soldering the fine-pitch leads of the SSOP package, carefully check all individual pins to avoid possible shorts at start-up. Finish the SMD parts before moving to the through hole components (C4,5,7,8, and U6). The second chip is a regular SO08 package, with a lower density than the SSOP.

After the SMD parts are mounted, you may want to use a larger size soldering iron for the through hole components. Once all parts are stuffed, installation of the USB hardware on a PC is the next step.

Installation and Testing

Hooking up the unit to a PC's USB port triggers an automatic installation process (Win98 or higher). Under the category 'USB audio device,' the board is recognized and becomes accessible under 'Control panel'-'Audio devices.' Parameters such as volume, balance, etc., ... can be set and audio playback or recording should be possible.

Once attached onto the PC's USB board, the red LED lights for a couple of seconds and goes out after recognition, enabling the PC. If the LED stays on, there is something wrong. Check the VBUS voltage (+5V) and VCCI (+3.3V) first and make sure the PCM2900 is receiving the correct DC volt-

ages. Also, check the individual pins of the SSOP package (soldering okay, shorts?). The PCM2900 needs the right DC voltages and USB data to become operational. The DA section can be tested by generating test sequences on the PC and analyzing the analog signal on an audio tester (analog stereo output). The AD section can be analyzed by generating a reference signal on the analog input of the unit and utilizing audio analysis software on a PC. More info on audio testers and test sequences can be found on the following websites:

www.sumuller.de/audiotester

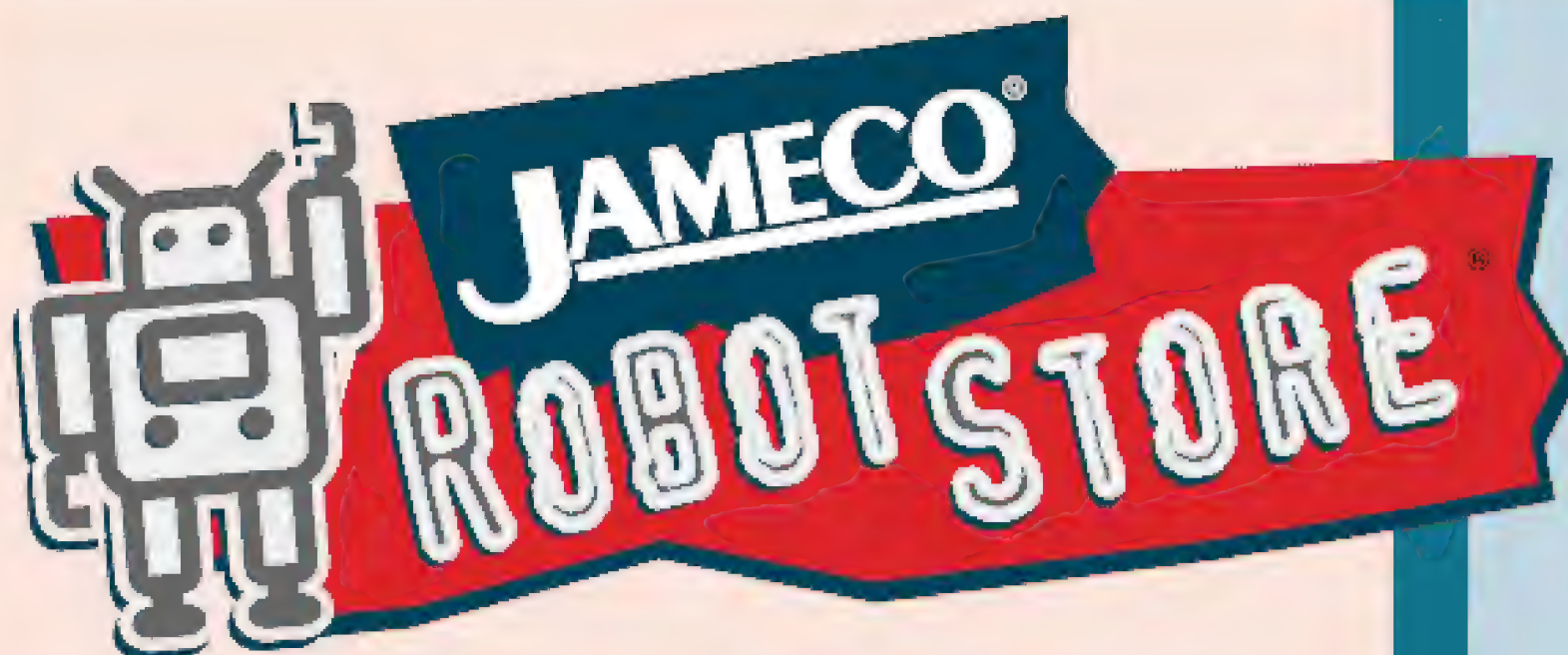
www.blazeaudio.com/downloads/index.html

www.tracertek.com/audio_testing.htm

Karaoke, anyone? **NV**

References

- (1) Texas Instruments, *PCM2900 Stereo audio codec with USB interface*, May 2002, www.ti.com
- (2) Texas Instruments, *OPA2353 High-speed, single supply, rail-to-rail operational amplifiers*, March 1999, www.ti.com
- (3) FilterPro design program, www.ti.com
- (4) Author's website, <http://users.skynet.be/bestelectrix>



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Spoke Signals

LED Virtual Image Generators for Your Bicycle

Show Off Your Patriotism and Get in Shape at the Same Time!

You will be the center of attention when you ride by on your bicycle with this cool gizmo attached to your wheels. With the use of LEDs (Light Emitting Diodes), you can make patriotic images appear to be suspended in air as your wheels spin. This construction article describes “Spoke Signals” — a series of three LED virtual image generators for your bicycle (see Figures 1 and 2).

Each of the three “Spoke Signal” virtual image generators creates its own unique, dynamic, and eye-catching image, using just one or two columns of LEDs. The images are generated by a microprocessor programmed to precisely sequence a LED array to scan out a virtual picture when the generator is spun around on a bicycle wheel.

There are three different “Spoke Signal” images to choose from:

1. The USA flag
2. The Canadian flag
3. A peace symbol

Construction plans are included for each of the designs, as well as sources for the printed circuit board (PCB), parts, firmware, and complete kits.

How it Works

Just how does a virtual image generator work? In principle, an LED virtual image is generated much the same way a TV raster scans out a picture on a screen. In a TV, an electron beam is bent magnetically — both hori-

zontally and vertically — to cover the full viewing screen of the Cathode Ray Tube (CRT). The modulated electron beam stimulates the phosphors deposited on the inside screen of the CRT to emit colored light. The light (persistence of these phosphors and of your eye) paints an entire image for your brain to assemble into a picture.

On the Spoke Signal virtual image generator, columns of colored LEDs are rotated around an axis to paint a full image with every revolution of the wheel. A full column of LEDs makes up for not being able to vertically scan the image and the wheel rotation provides the equivalent to the horizontal scanning (see Figure 3).

As in your TV, the timing of how the LEDs are driven is extremely important to assure that the desired image is sequenced out perfectly every revolution. The key to driving the LEDs precisely is knowing exactly how fast the wheel is spinning. Once you know the time for one wheel revolution, the processor can easily calculate how fast to sequence the LEDs to paint the image. When done correctly, images are made to appear stable in mid-air, regardless of wheel speed.

Circuit Design

The design of each of the three Spoke Signal circuits is very simple and essentially the same. Each version uses a Microchip processor that controls each LED array directly and a magnetic reed switch is used to detect the speed of the wheel. The circuit board is mounted to the spokes on your bicycle wheel using tie-wraps. A magnet

is located on the wheel fork so that it activates the reed switch every wheel revolution.

Quality white and blue LEDs can still cost close to \$1.00 each, so this design keeps the number of LEDs to a minimum by making use of the fact that most T1 and T1-3/4 case-style LEDs emit a significant amount of light not only out the rounded top, but also out their flat bottom. The clever design of the PCB allows light to be viewed from both ends of each LED. Thus, only one set of LEDs is needed for viewing the same image from both sides of the wheel.

Figure 1. USA and Canadian Spoke Signal in operation on one wheel.



Figure 2. Spoke Signal mounted on a 1948 Schwinn. (What could be more patriotic?)



Spoke Signals

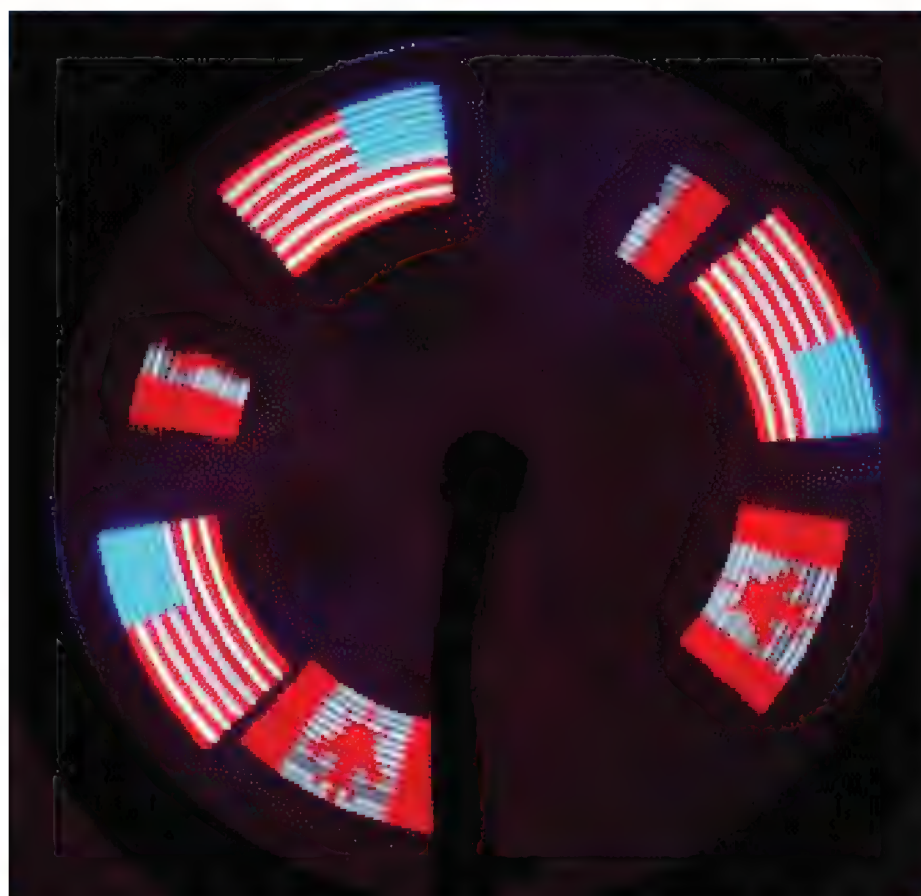


Figure 3. A partially drawn virtual image taken with a faster shutter speed.

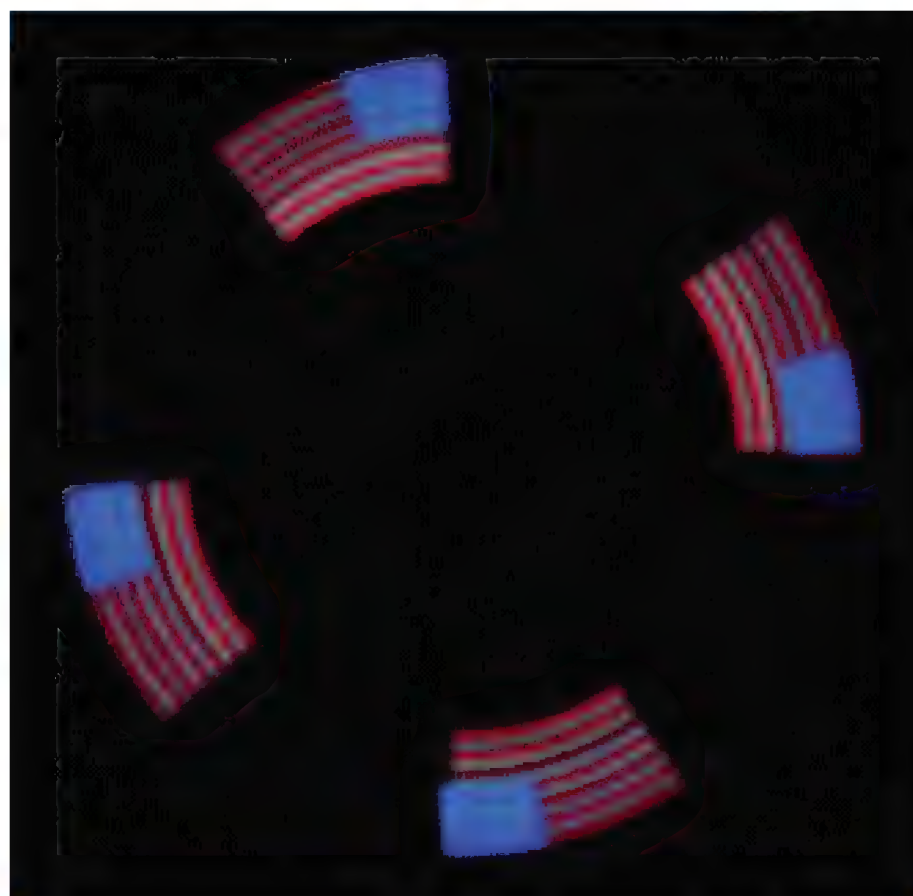


Figure 4. USA Flag Spoke Signal showing entire wheel.

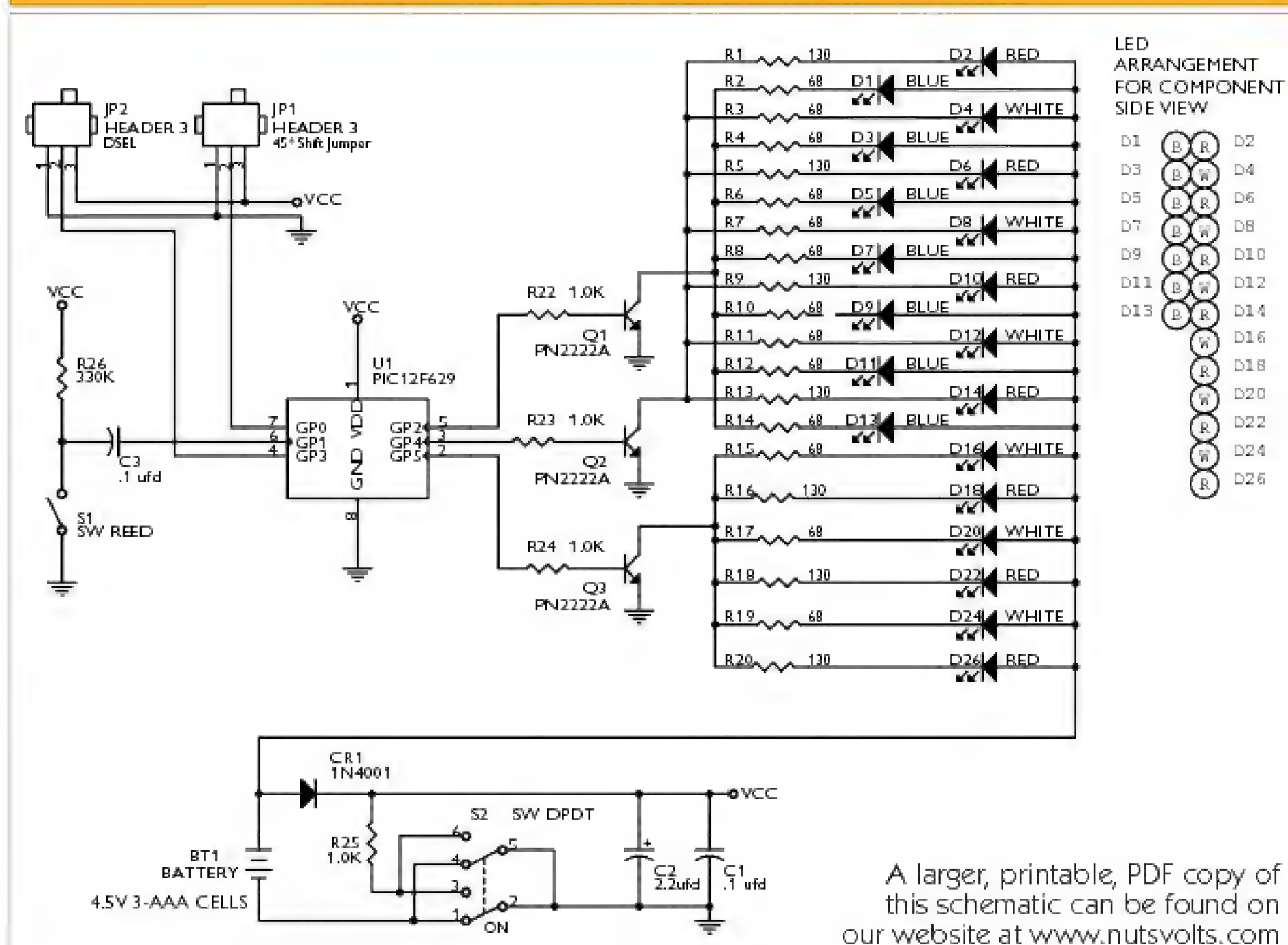
Looking at each of the schematics, the core circuit designs are not complicated and consist of a reed switch for measuring wheel RPM, a battery power supply and, of course, the processor for driving a LED array. The reed switch is capacitively coupled to the Microchip PIC input. This helps reduce power consumption if the reed switch is parked under the magnet.

The PIC is programmed to respond to an internal hardware flag generated by a change of logic level on reed switch input so there is no chance of missing the magnet. The reed

switch performs very well, even in the high vibration environment of a bicycle wheel. No false triggering of the circuit was observed even when riding our test bike up and down railroad tracks!

The whole circuit operates off three 1.5V AAA cells for a total of 4.5 volts, since these PICs can operate down to three volts or less. The 1N4001 diode is necessary to isolate the PIC from the battery so that dips in the battery voltage due to groups of LEDs turning on and off will not upset the processor's operation. Note the 1K resistor connected to the "Off"

Figure 5. Schematic for the Spoke Signal USA flag.



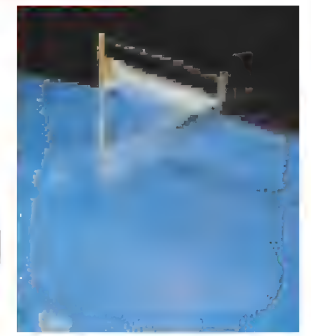
A larger, printable, PDF copy of this schematic can be found on our website at www.nutsvolts.com

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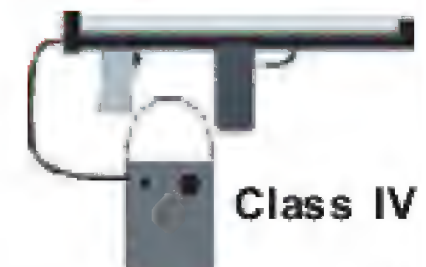
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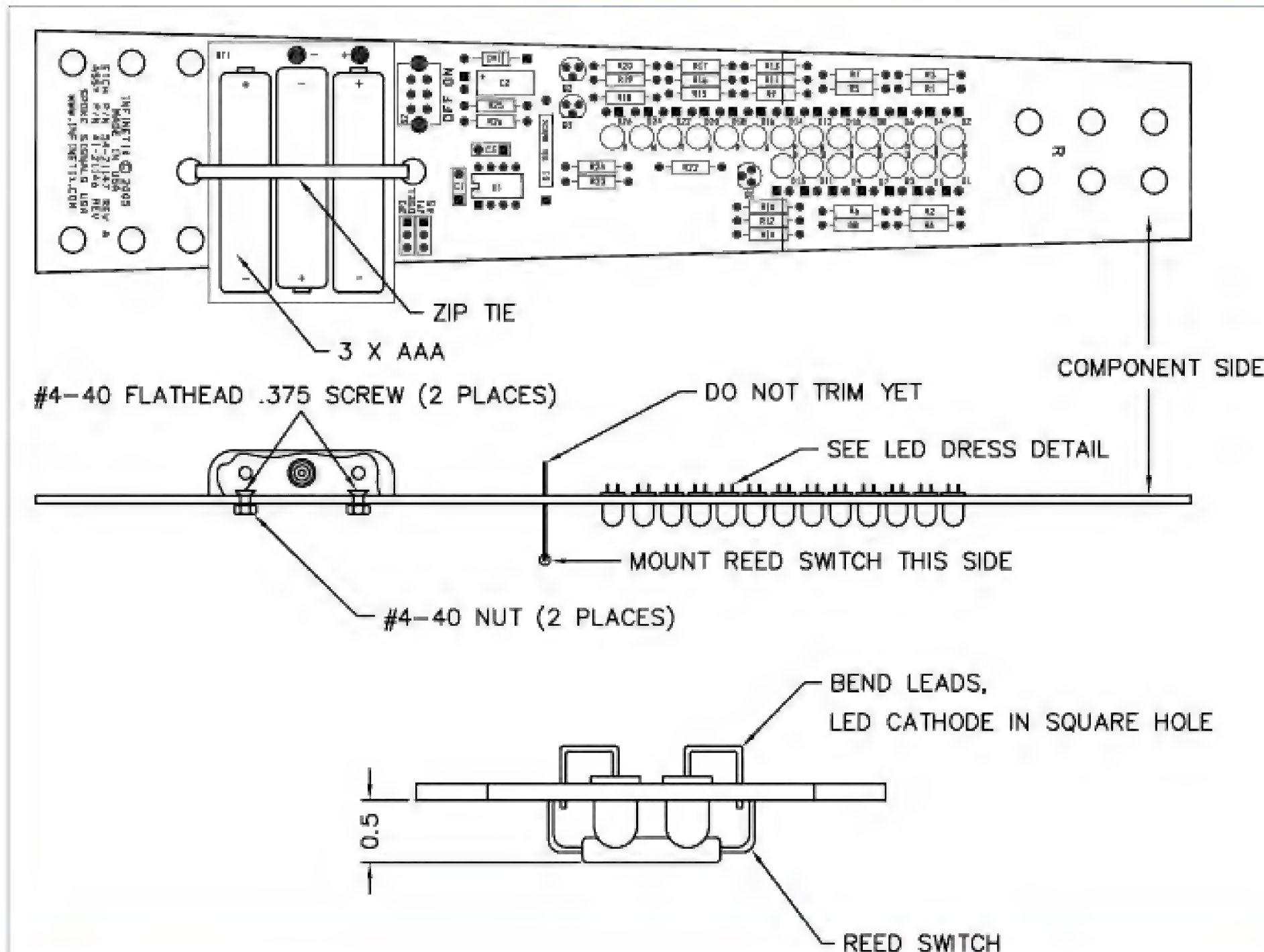


Figure 6. Assembly drawing for the Spoke Signal USA flag.

side of the power switch. This will bleed any residual voltage on the processor Vcc when the unit is off so it will power-up properly the next time power is applied. This trick was necessary to assure proper operation of the internal reset circuit of the PIC.

Lastly, note that these PICs do not have any crystal to clock the processor's operation. This is because each of these PICs contain an internal 4-MHz oscillator. Both the

and seven blue LEDs arranged in a full column of red and white alternating LEDs and a partial column of blue LEDs. A schematic, board layout, and parts list for the USA flag version are shown in Figures 4, 5, 6, and 7.

For the "Canadian" Spoke Signals Flag, multiplexing the LEDs in three groups of eight was necessary as the Canadian Flag requires more control over each individual LED to draw out the maple leaf. This LED arrangement is a column of 12 red and 12 white LEDs for a total of 24 LEDs. The additional requirements for this flag required the use of a PIC16F627 with more pins.

PICs have the ability to sink 25 mA of current on every I/O pin to drive LEDs directly, so drivers for each individual LED were not needed. PN2907 transistors are used to source current for each group of eight LEDs and each LED group is switched on, then off, one at a time during the firmware's regular multiplex cycles. Designing the LED multiplexing into the firmware greatly reduces circuit complexity and cost. A schematic, board layout, and parts list for the Canadian flag version are shown in Figures 8, 9, 10, and 11.

Last, but not least, the "Peace" Spoke Signal uses only a single column of 16 LEDs, but still requires multiplexing the LEDs in two groups

internal reset circuit and the internal oscillator are options that are selected when the part is programmed.

Different Strokes for Different Spokes

Each Spoke Signal variation differs only in how the LEDs are driven by the firmware and the colors of the LEDs used to compose a specific image. Those differences are described next.

The Spoke Signal's "USA" flag is actually the simplest LED drive and firmware configuration. Three different LED groups are used to generate the USA flag. This configuration required three PN2222A drive transistors due to the amount of current needed to drive each LED group. The eight-pin PIC12F629 processor had plenty of horsepower for this job. You will notice from the schematic that this version has seven red, six white,

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of eight and therefore, a PIC16F627 is needed. A schematic, board layout, and parts list for the "Peace" version are shown in Figures 12, 13, 14, and 15.

Firmware

The microprocessor firmware is, of course, key to the overall operation and hardware simplicity of a Spoke Signal display. The flowcharts in Figure 16 describe the firmware's basic operation. The firmware must precisely track the wheel speed and time when a different pixel data group must be sequenced out to the LEDs. Image data is stored in a look-up table and the processor does all timing-critical processes in an interrupt routine. In order to keep

the firmware as simple as possible, the wheel was divided up into 256 pixels so that the individual pixel time calculation is a simple matter of taking the total "wheel revolution time" and dividing by 256. This is easily accomplished by shifting right eight bits the "wheel revolution time" variable to get the individual "LED pixel time."

Construction

Building a Spoke Signal is relatively simple, but does require some reasonable attention to the exact mechanical location of each LED. Each T1-3/4 LED should be spaced 0.225" away from each other and the relative position of each LED is detailed on each schematic. If you are going

Qty	Reference	Description	Manufacturer: P/N	Vendor	Vendor P/N
1	BT1	Battery Holder, 3 Cell AAA PC MNT	Keystone: 2479	Digi-Key	2479K-ND
1	CR1	Diode, 1N4001 1AMP 50PRV	Rectron: 1N4001-B	Mouser	583-1N4001-B
2	C1, C3	Capacitor, 0.1ufd 50V Radial	AVX: SR205E104MA	Mouser	581-SR205E104M
1	C2	Capacitor, 2.2ufd 25V Radial	Xicon: XRL25V2.2	Mouser	140-XRL25V2.2
7	D1, D3, D5, D7, D9, D11, D13	BLUE LED, T1 3/4 (5mm)	Everlight: 383-2SUBCC470S	Mouser	638-383-2SUBCC470S
7	D2, D6, D10, D14, D18, D22, D26	RED LED, T1 3/4 (5mm)	Everlight: 333-2SURCS5306	Mouser	638-333-2SURCS5306
6	D4, D8, D12, D16, D20, D24	WHITE LED, T1 3/4 (5mm)	Everlight: 333-2UWCS400	Mouser	638-333-2UWCS400
3	Q1, Q2, Q3	Transistor, PN2222A 40V 1A NPN	Fairchild: PN2222ANLBU	Mouser	512-PN2222ANLBU
7	R1, R5, R9, R13, R16, R18, R20	Resistor, 130 ohm 1/4W		Mouser	291-130
13	R2, R3, R4, R6, R7, R8, R10, R11, R12, R14, R15, R17, R19	Resistor, 68 ohm 1/4W		Mouser	291-68
4	R22, R23, R24, R25	Resistor, 1.0K ohm 1/4W		Mouser	291-1K
1	R26	Resistor, 330K ohm 1/4W		Mouser	291-330K
1	S1	Switch, Reed Magnetic SPST 14-23AT	Coto Tech: RI-01BAA	Digi-Key	306-1168-ND
1	S2	Switch, DPDT PC MNT ON-ON	Mountain Switch: 10SP020	Mouser	10SP020
1	U1	Microcontroller	Microchip: PIC12F629IP	Mouser	579-PIC12F629IP
1	BD1	PCB or Perf Board		Infinetix	54-21147
2	Screw	4-40 flathead x 3/8"		Hardware store	
2	Nut	4-40 NUT		Hardware store	
2	Lockwasher	#4 Star Washer		Hardware store	
5	Tie-wrap	3" TIE WRAPS		Hardware store	
1	Magnet	MAGNET		Hardware store	

Each separate Spoke Signals kit (available from Infinetix Corp.) includes: 1) A plated-through PCB fully drilled with solder mask and silk screening for easy parts placement and assembly. 2) All components listed in the respective Parts List. 3) Firmware programmed into the microcontroller. Spoke Signals USA flag, Canada flag, or Peace Symbol fully assembled and tested \$41.00 USD/each. Spoke Signals USA flag, Canada flag, or Peace Symbol bare PCB \$11.00 USD/each. (WA state residents add 8.1% sales tax.) US orders add \$5.00 USD for shipping and handling. Canada and Non-US orders add \$9.00 USD for shipping and handling. Please allow three to five weeks for delivery.

Mail orders to: Infinetix Corp., 2721 N. Van Marter #3, Spokane, WA 99206

Check out www.infinetix.com to place orders and to download processor Hex files for the Spoke Signals projects.

KIT PRICES

Spoke Signals USA flag kit \$28.50 USD
Spoke Signals Canada flag kit \$28.50 USD
Spoke Signals Peace Symbol kit \$26.00 USD

*This information
applies to all
Parts Lists.*

Figure 7. Parts List and Sources for the Spoke Signal USA flag.

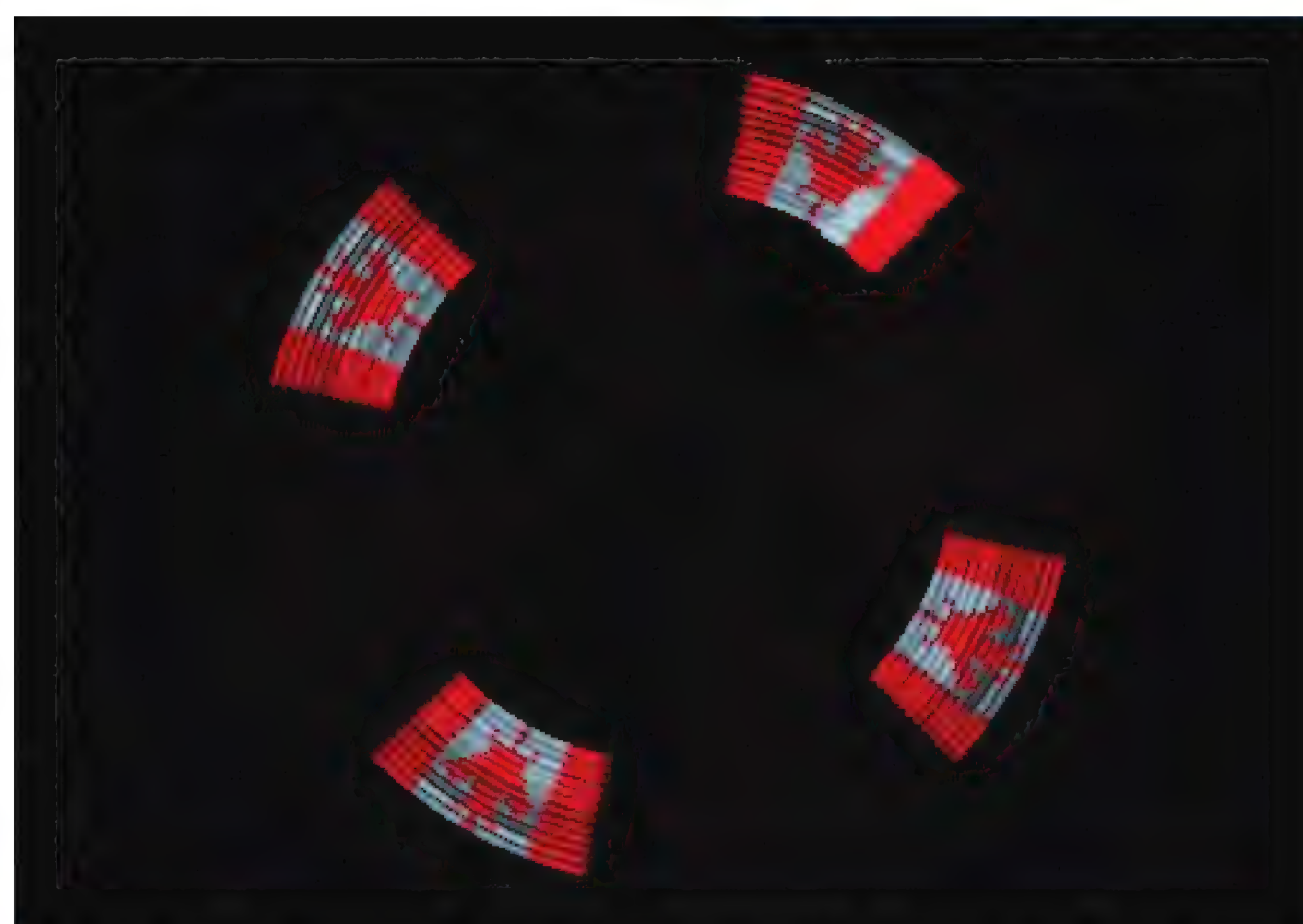


Figure 8. Spoke Signal Canadian flag showing entire wheel.

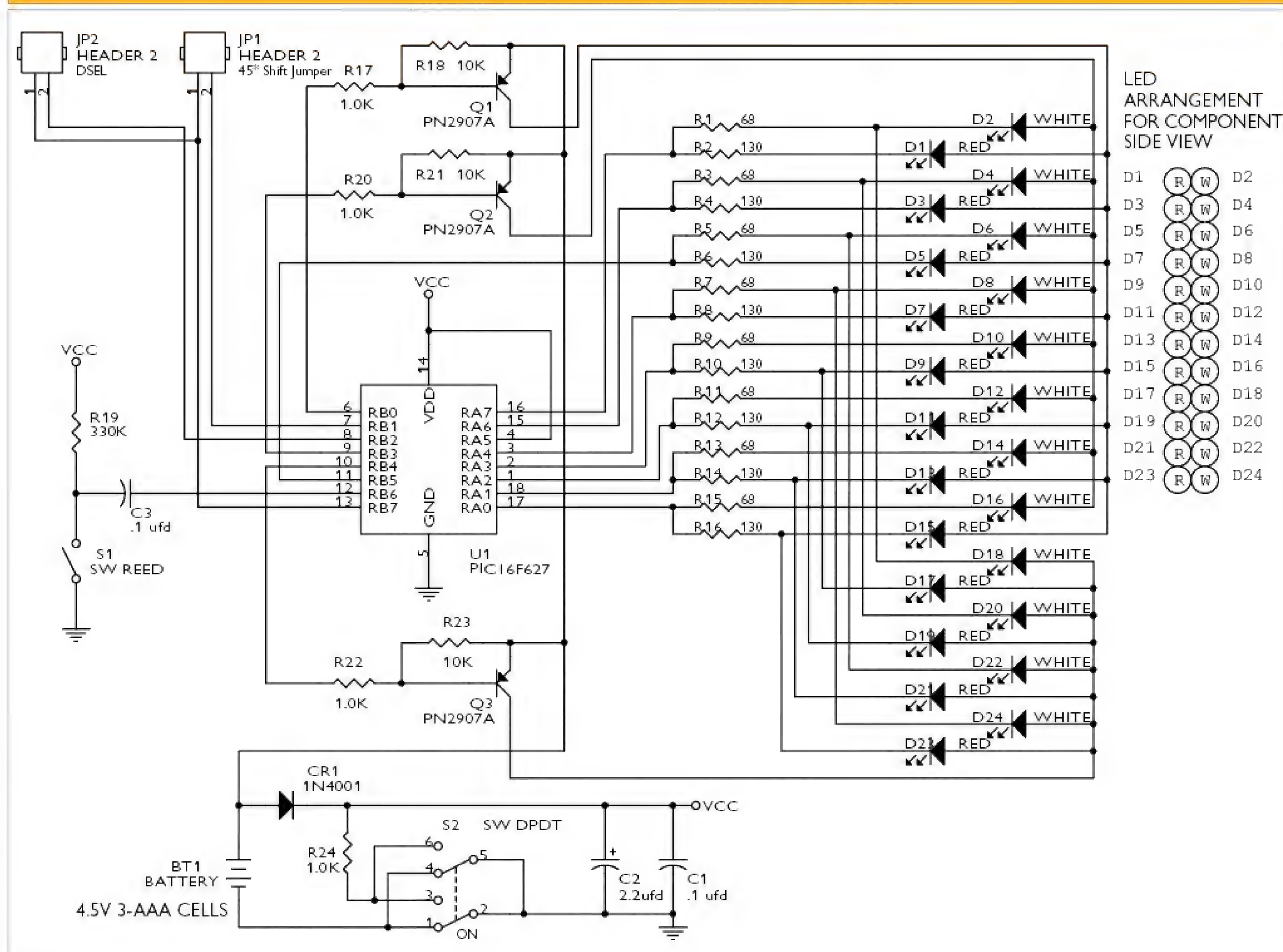
to hand-wire the circuit, then some careful mechanical layout and hole drilling will be required. This is one detail that is greatly simplified if you have an actual PCB.

Since the LEDs are key to this project don't skimp here. There are plenty of sources for bright LEDs in lots of colors. LEDs with a wide viewing angle are also desirable. Watch the colors you get; some companies advertise "red" LEDs that are more orange than red or white LEDs with a yellow tinge. In general, all the components are easily found and each parts list gives some good sources.

Wire and solder all the other components approximately as shown on the layout drawings. Note that the position of the reed switch is such that it passes under the magnet attached to the bike fork. I found a magnetic reed switch worked very well for a speed sensor, but remember that the envelope of the reed is just glass and will break if the leads are stressed too much against the glass.

It is wise to make bends in the leads with two needle nose pliers so no stress will be applied to the glass envelope. Do not cut the excess leads off the reed switch so the switch's height can be adjusted to your specific wheel and fork configuration. Lastly, don't forget to program the PIC before you solder it in.

Figure 9. Schematic for the Spoke Signal Canadian flag.



Testing the Circuit

To test the circuit, simply install the batteries and turn on the switch. Take a magnet and pass it over the reed switch. The LEDs should start flashing in bursts. The faster the reed switch closures, the closer the spacing of the bursts of light. If some LEDs stay on or do not light at all, check for solder bridges, wiring errors, and incorrect LED polarity as these will be the most common mistakes made.

Installation

The reed switch is mounted on the opposite side of the PCB so that most of the components will be protected when mounted as shown on a wheel. See Figures 17, 18, 19, and 20. The PCB is mounted to the spokes of your bicycle wheel with nylon tie-wraps and the

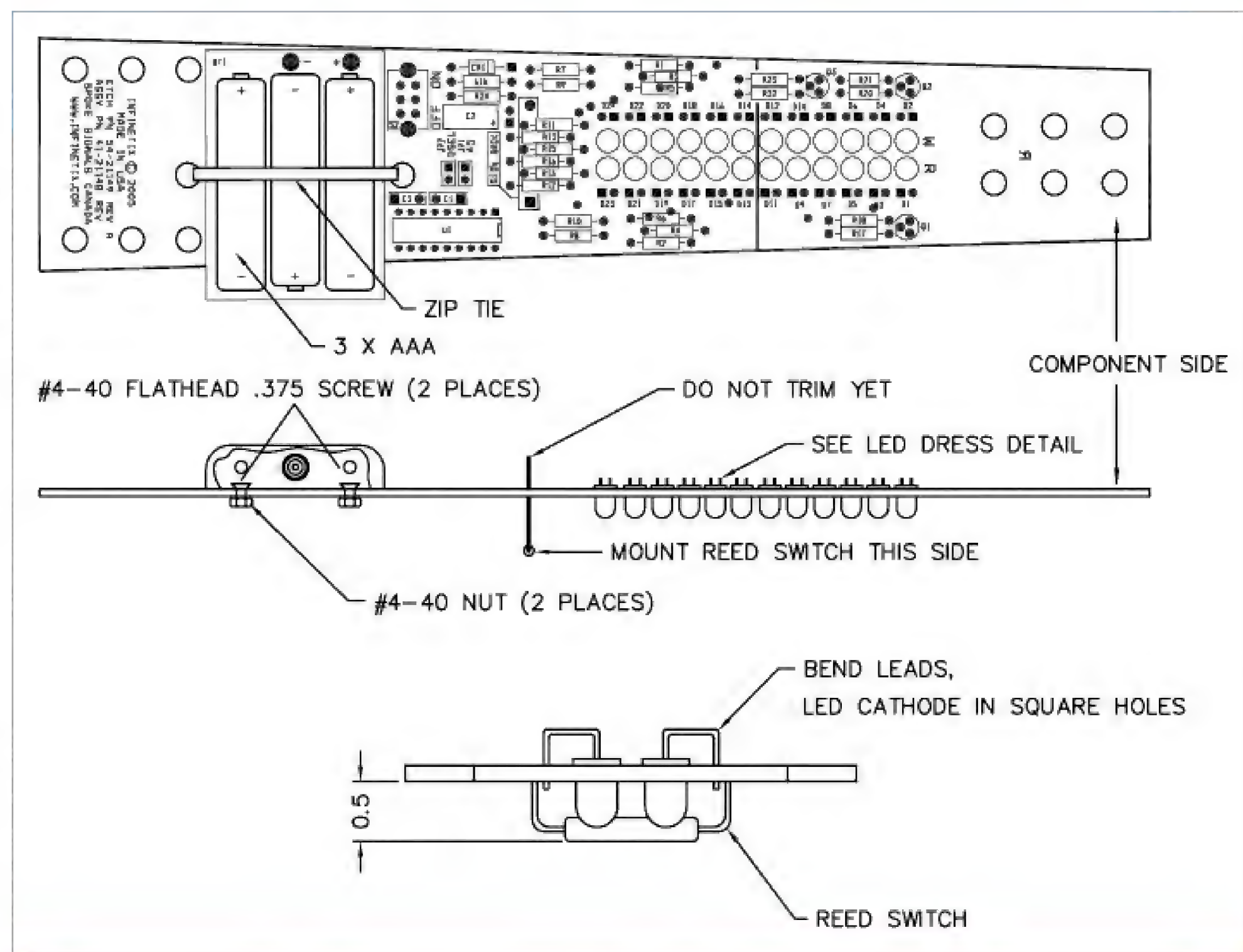


Figure 10. Assembly drawing for the Spoke Signal Canadian flag.

Qty	Reference	Description	Manufacturer: P/N	Vendor	Vendor P/N
1	BT1	Battery Holder, 3 Cell AAA PC MNT	Keystone: 2479	Digi-Key	2479K-ND
1	CR1	Diode, 1N4001 1AMP 50PRV	Rectron: 1N4001-B	Mouser	583-1N4001-B
2	C1, C3	Capacitor, 0.1ufd 50V Radial	AVX: SR205E104MAA	Mouser	581-SR205E104M
1	C2	Capacitor, 2.2ufd 25V Radial	Xicon: XRL25V2.2	Mouser	140-XRL25V2.2
12	D1, D3, D5, D7, D9, D11, D13, D15, D17, D19, D21, D23	RED LED, T1 3/4 (5mm)	Everlight: 333-2SURC/S530-A6	Mouser	638-333-2SURCS5306
12	D2, D4, D6, D8, D10, D12, D14, D16, D18, D20, D22, D24	WHITE LED, T1 3/4 (5mm)	Everlight: 333-2UWC/S400-A5	Mouser	638-333-2UWCS400
3	Q1, Q2, Q3	Transistor, PN2907A -60 -0.6A PNP	STMicro: PN2907A	Mouser	511-PN2907A
8	R1, R3, R5, R7, R9, R11, R13, R15	Resistor, 68 1/4W		Mouser	291-68
8	R2, R4, R6, R8, R10, R12, R14, R16	Resistor, 130 1/4W		Mouser	291-130
4	R17, R20, R22, R24	Resistor, 1.0K 1/4W		Mouser	291-1K
3	R18, R21, R23	Resistor, 10K 1/4W		Mouser	291-10K
1	R19	Resistor, 330K 1/4W		Mouser	291-330K
1	S1	Switch, Reed Magnetic SPST 14-23AT	Coto Tech: RI-01BAA	Digi-Key	306-1168-ND
1	S2	Switch, DPDT PC MNT ON-ON	Mountain Switch: 10SP020	Mouser	10SP020
1	U1	Microcontroller	Microchip: PIC16F627-04/P	Mouser	579-PIC16F62704P
1	BD1	PCB or Perf Board		Infinitix	54-21149
2	Screw	4-40 flathead x 3/8"		Hardware store	
2	Nut	4-40 NUT		Hardware store	
2	Lockwasher	#4 Starwasher		Hardware store	
5	Tie-wrap	3" TIE WRAPS		Hardware store	
1	Magnet	Magnet		Hardware store	

Figure 11. Parts List and Sources for the Spoke Signal Canadian flag.



Figure 12. Spoke Signal peace symbol showing entire wheel.

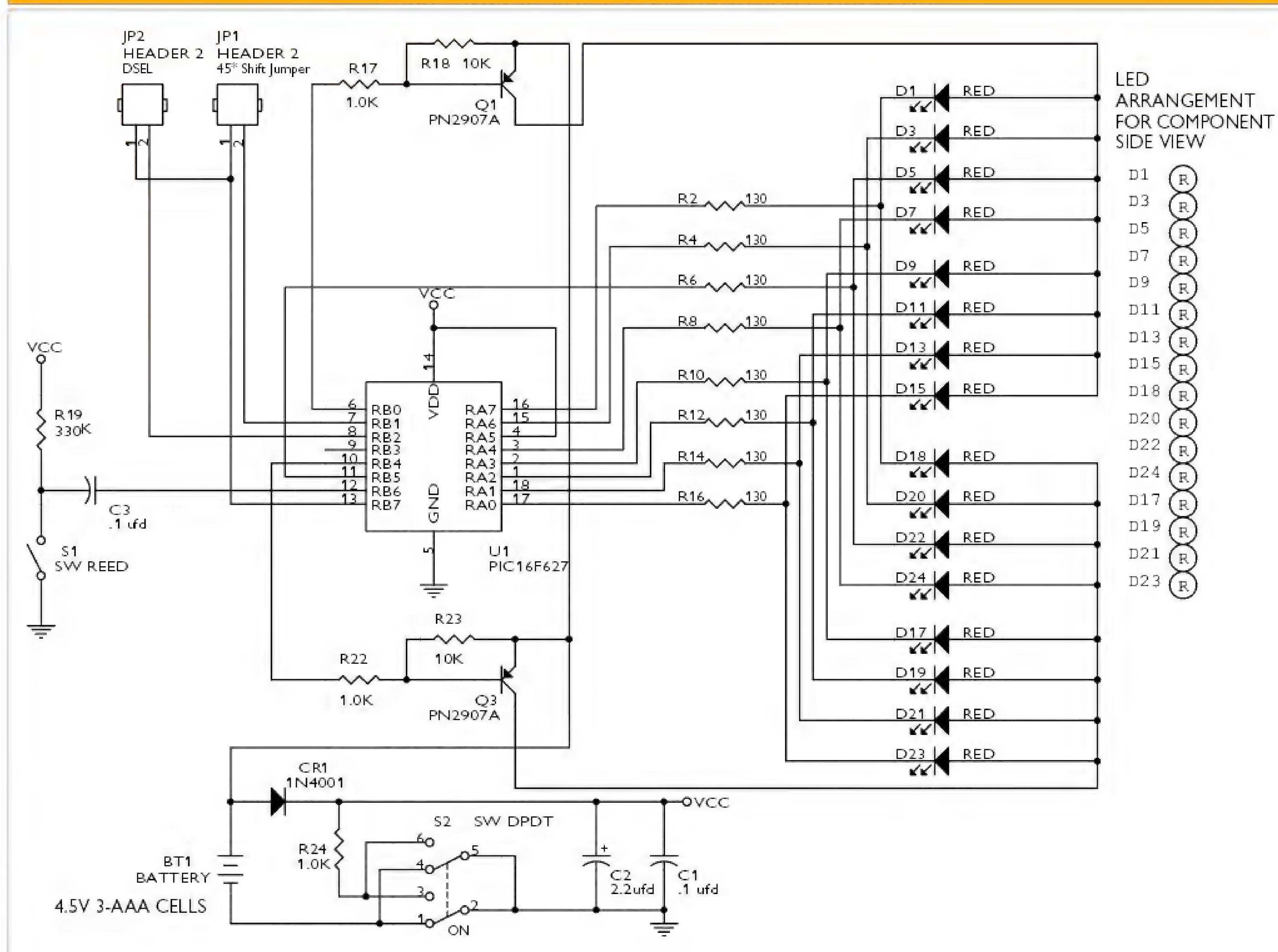
board has extra holes to provide lots of mounting options. Don't forget to put tie-wraps on the batteries, as any bump will knock them out of their holder. The PCB is long

enough so that you can fine-tune the board position to make sure the middle of each LED array is located 8.5" from the wheel center. Just trim off any extra PCB and snug up the three tie-wraps, so centrifugal force will not be able to shift the PCB out of place. You should not have a problem locating the PCB on a 26" or larger bike wheel.

Lastly, locate a suitable magnet on the inside of the wheel fork so that it will pass over the top of the reed switch. You may need to adjust the height of the reed switch to locate it close enough to the fork-mounted magnet. I found that super-glue works fine for attaching the magnet to the inside of the wheel fork. Most reed switches will generate an audible "click" when the magnet opens and closes the switch, so it should be easy to tell if the magnet and reed switch are properly positioned with respect to each other.

With the installation done, turn on the switch and give the wheel a spin. You ought to be able to see your "Spoke Signal" image. On the Canadian and USA flag versions, direction of spin does matter. Gaps of black between the colored fields are an indication that you need to change

Figure 13. Schematic for the Spoke Signal peace symbol.



the side of the wheel the PCB is mounted on. The PCB is labeled left (L) and right (R) so it is easy to get it correct.

Mixing Signals

There is one jumper option to the processor. If you short the jumper marked 45, the image will shift 45 degrees so that any one Spoke Signal display can be mixed with any other version. You can then mix the two flags on one bike wheel if you wish and trigger their operation from the same magnet. Just remember to mount the units 180 degrees from each other. Remember that the processor goes to sleep and turns off the display after two minutes of no reed switch activity. The display will turn right back on once the magnet closes the reed switch. The current consumption of

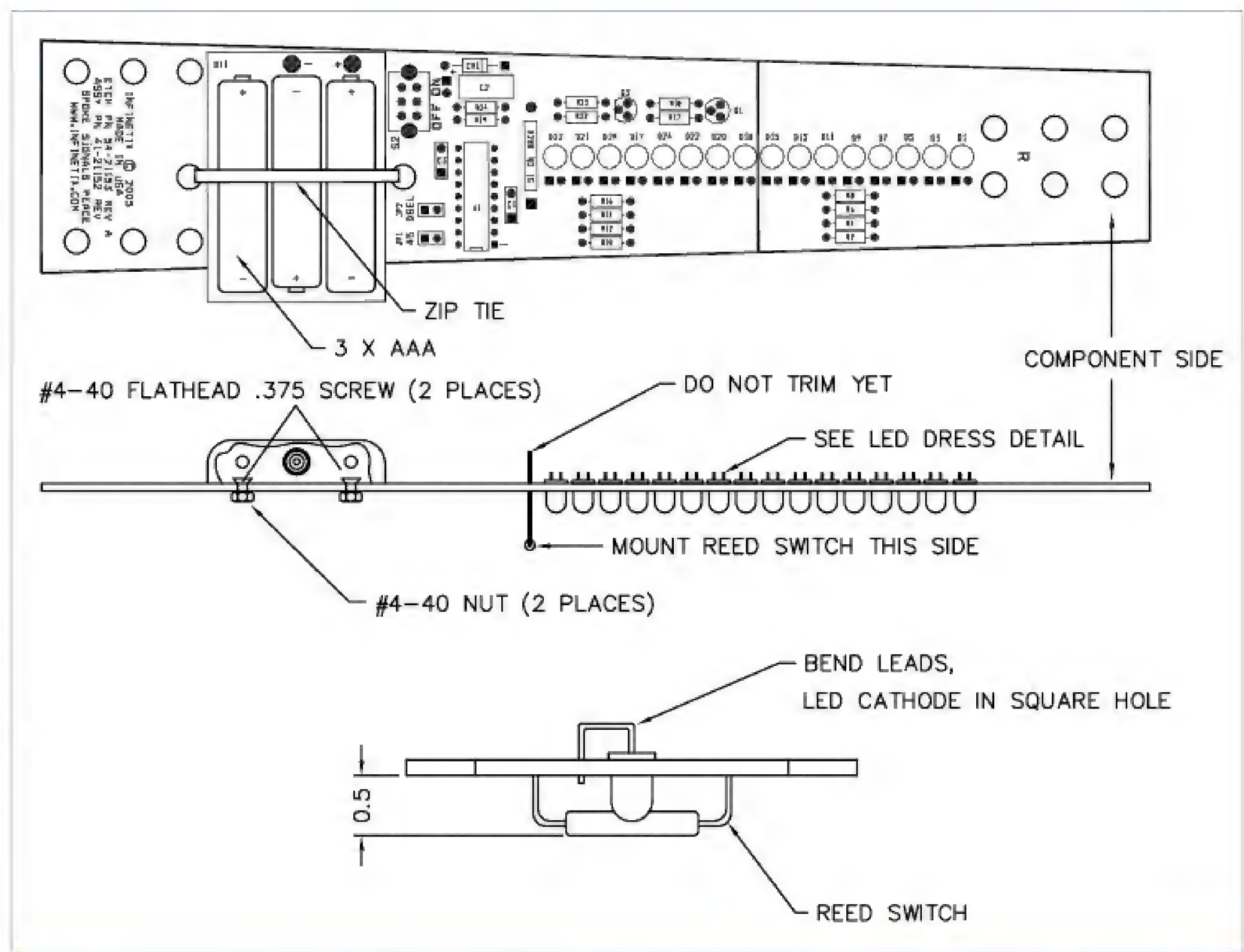


Figure 14. Assembly drawing for the Spoke Signal peace symbol.

Qty	Reference	Description	Manufacturer: P/N	Vendor	Vendor P/N
1	BT1	Battery Holder, 3 Cell AAA PC MNT	Keystone: 2479	Digi-Key	2479K-ND
1	CR1	Diode, 1N4001 1A 50V	Rectron: 1N4001-B	Mouser	583-1N4001-B
2	C1, C3	Capacitor, Ceramic 0.1ufd 50V Radial	AVX: SR205E104MAA	Mouser	581-SR205E104M
1	C2	Capacitor, Electrolytic 2.2ufd 25V Radial	Xicon: XRL25V2.2	Mouser	140-XRL25V2.2
16	D1, D3, D5, D7, D9, D11, D13, D15, D17, D18, D19, D20, D21, D22, D23, D24	RED LED, T1 3/4 (5mm)	Everlight: 333-2SURC/S530-A6	Mouser	638-333-2SURCS5306
2	Q1, Q3	Transistor, PN2907A -0.6A -60V PNP	STMicro: PN2907A	Mouser	511-PN2907A
8	R2, R4, R6, R8, R10, R12, R14, R16	Resistor, 130 1/4W		Mouser	291-130
3	R17, R22, R24	Resistor, 1K1/4W		Mouser	291-1K
2	R18, R23	Resistor, 10K 1/4W		Mouser	291-10K
1	R19	Resistor, 330K 1/4W		Mouser	291-330K
1	S1	Switch, Reed Magnetic SPST 14-23AT	Coto Tech: RI-01BAA	Digi-Key	306-1168-ND
1	S2	Switch, DPDT PC MNT ON-ON	Mountain Switch: 10SP020	Mouser	10SP020
1	U1	Microcontroller	Microchip: PIC16F627-04/P	Mouser	579-PIC16F62704P
1	BD1	PCB or Perf Board		Infinetix	54-21253
2		4-40 flathead x 3/8"		Hardware store	
2		4-40 NUT		Hardware store	
2		#4 Starwasher		Hardware store	
5		3" TIE WRAPS		Hardware store	
1		MAGNET		Hardware store	

Figure 15. Parts List and Sources for the Spoke Signal peace symbol.

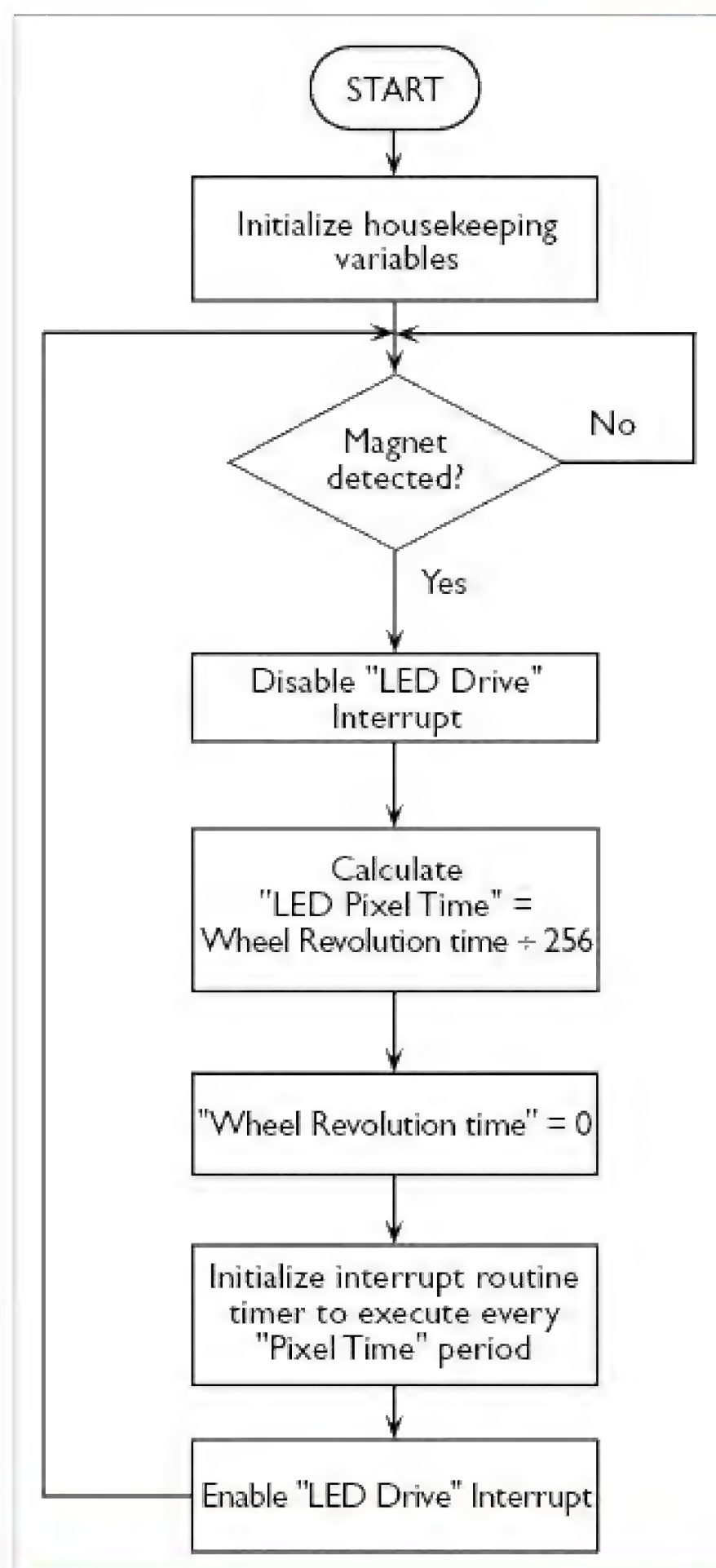


Figure 16. Spoke Signal firmware flowchart diagram.

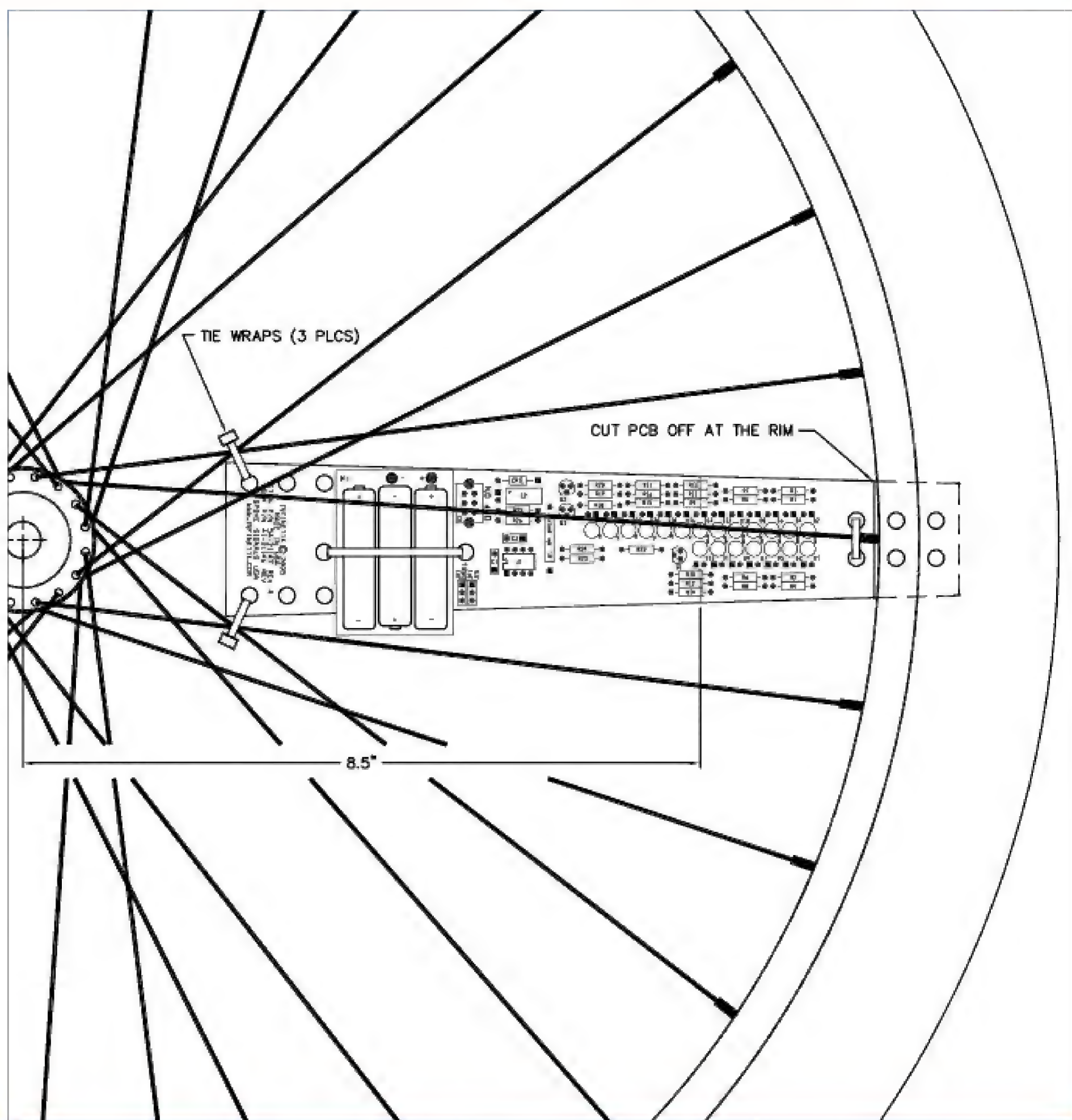


Figure 17. Diagram for mounting the Spoke Signal PCB on a bike wheel.

each unit is very low when the unit goes to sleep, so even if your Spoke Signal is accidentally left on the batteries will still be in good shape for your next ride.

Please note that “Spoke Signal” displays are NOT meant to be safety devices. A helmet should always be worn when riding a bicycle. There is no substitute for

wearing a helmet, having and using a bicycle headlight, and using common sense in the safe operation of a bicycle. Remember to obey all local traffic laws.

Ooohhs and aaahhhs will abound in your summer holiday celebrations when you ride by with a Spoke Signal, so have fun! **NV**

Figure 18. Close-up of the PCB board mounted onto the spokes.

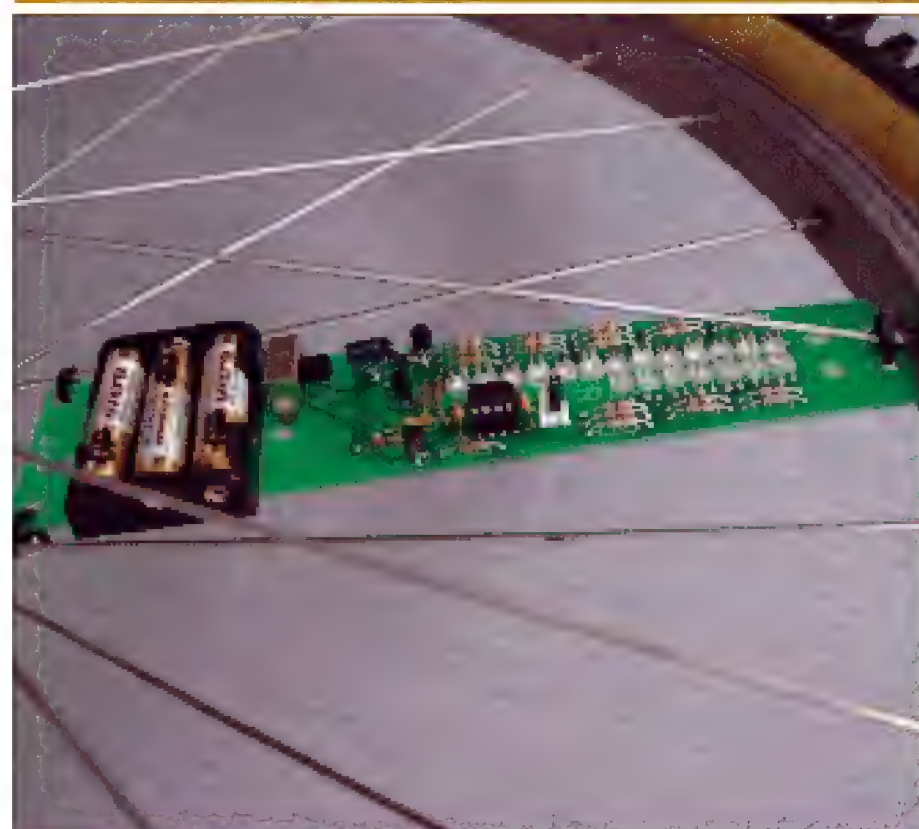
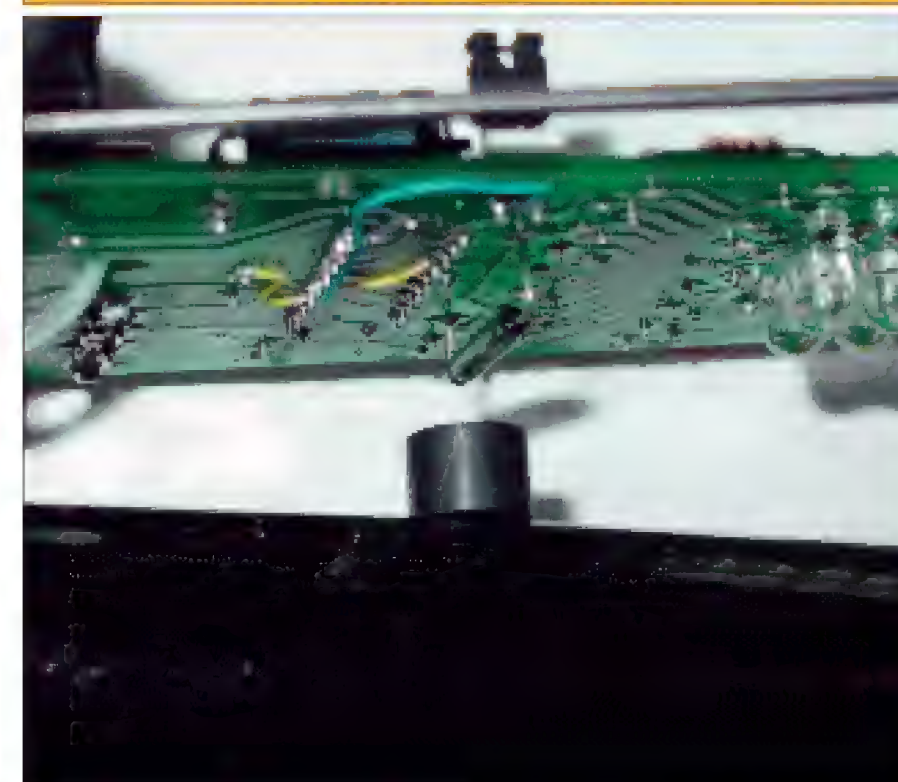


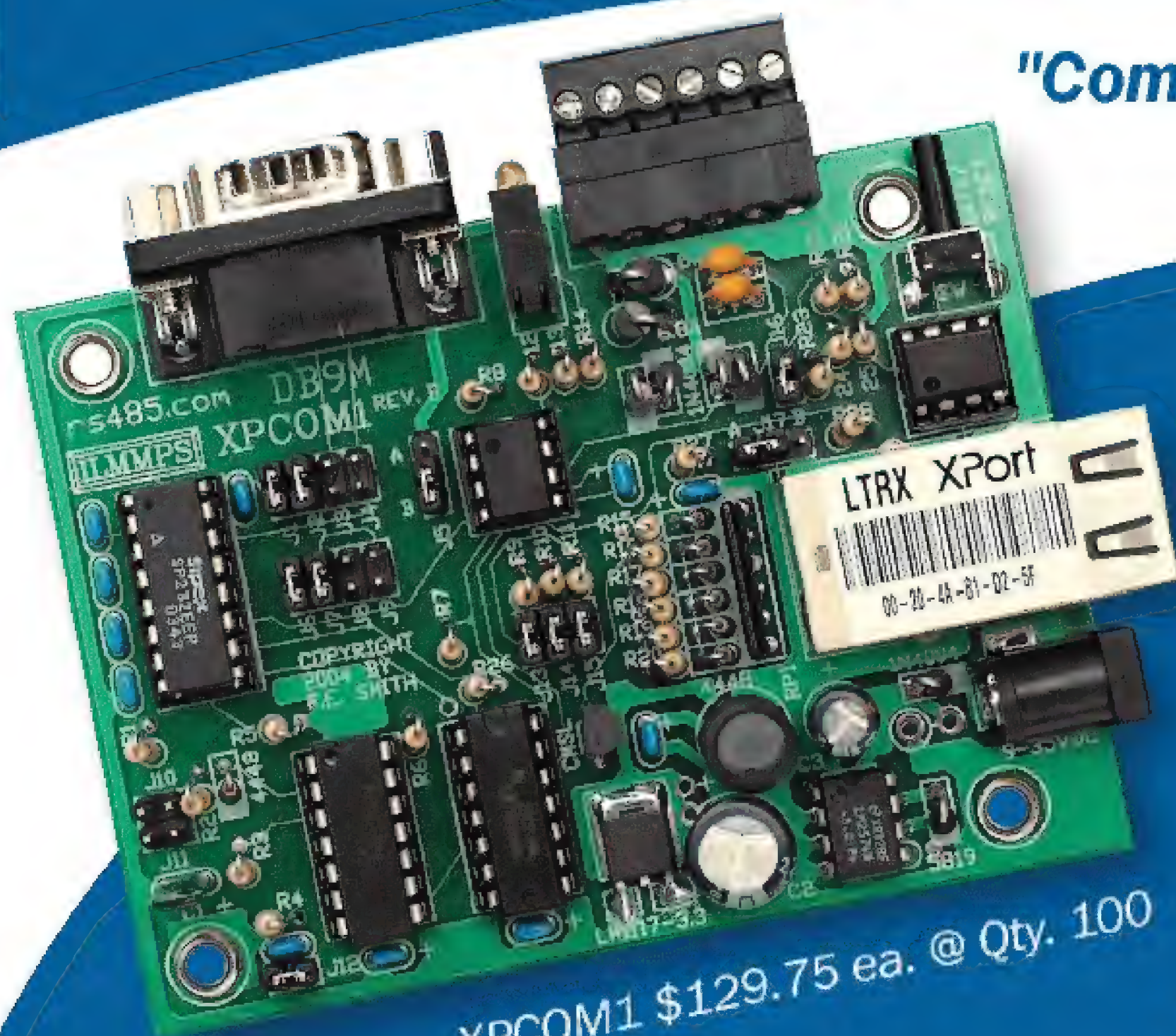
Figure 19. Side view of the mounted PCB to the wheel spokes.



Figure 20. Close-up of the mounted magnet and the relationship to the reed switch on the PCB.



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CONVERGENCE 2004

Vehicle Electronics to Digital Mobility: The Next Generation of Convergence

by Chuck Hellebuyck

When Nuts & Volts asked me to cover Convergence 2004, I said no problem. I usually go there every couple years and I was due to visit again. The show had some very interesting items for the Nuts & Volts reader. First though, let me tell you what Convergence is, in case you aren't familiar with it.

Convergence History

In the early 1970s, the US Government began regulating the automotive industry business for vehicle safety, fuel economy, and vehicle emission performance. Back then, vehicles did burn a lot of gas and the emissions were poor. Detroit turned to electronics to help solve the problem but mechanical engineers controlled most of the automotive design, not electrical engineers. This created a culture clash that Trevor Jones (now chairman and CEO of BIOMECH, Inc.) and a handful of other automotive engineers tried to solve by bringing the two factions together in a convergence of talent. The Convergence show was launched and this year marks its 30th anniversary.

Theme of Convergence 2004

If you've ever been to an SAE (Society of Automotive Engineers) show, then Convergence is a subset of that as seen in Figure 1. Almost every vendor has some connec-

tion to electronics, be it test equipment or components or even robotics (that's right, robotics). I saw more robotic related items than ever before as vehicles evolve into control systems similar to autopilot on an airplane.

Whether you realize it or not, several vehicles on the road already have the engine throttle controlled via electrical feedback only, called "drive by wire." Braking systems are anti-skid systems that rely heavily on a microcontroller controlling the application of the brake pads. Mechanical systems are still there for now, but a big push is on to make these "brake by wire," as well. "Steering by wire" is not far behind. If you control the power train, steering, and braking via a microcontroller, then a vehicle doesn't stray far from a semi-autonomous, digitally-controlled robot. In fact, this was the theme of Convergence 2004 — Vehicle Electronics to Digital Mobility: The Next Generation of Convergence.

Microchip/Taos

Robotics at the show was very apparent. When you



FIGURE 1

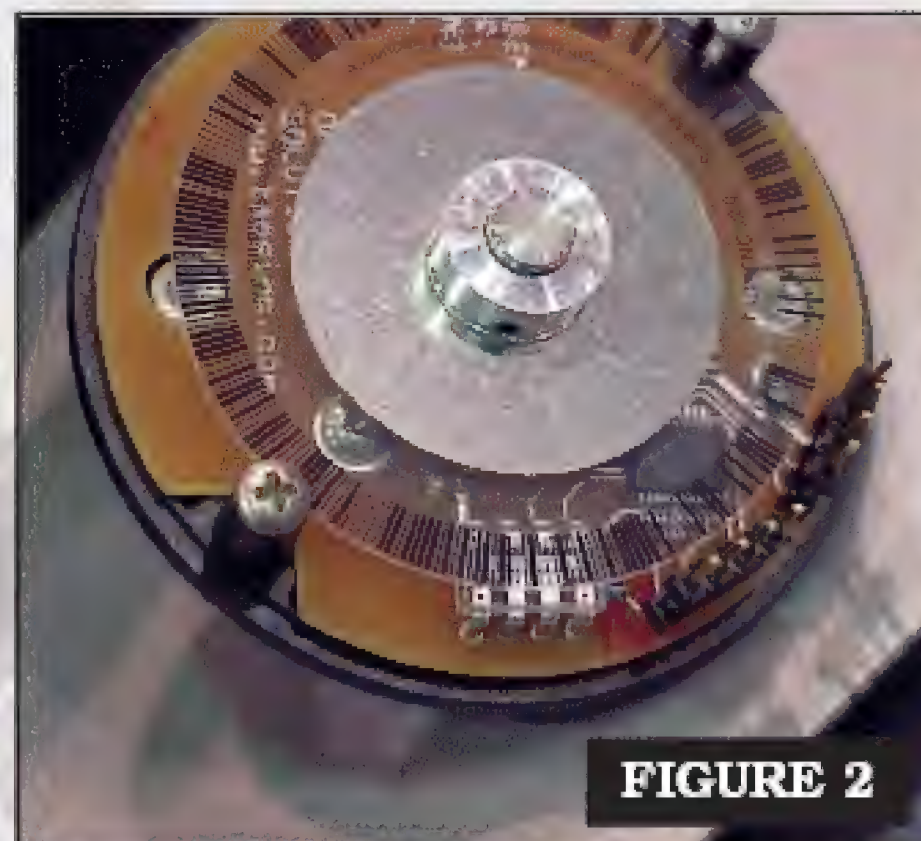


FIGURE 2



FIGURE 3

CONVERGENCE

first arrived at the Convergence entrance, a couple of local high school F.I.R.S.T. robot entries were on display and participants were giving brief demonstrations. From there, the show had vendors from all areas of electronics. My first stop was to my favorite booth: Microchip's display. I was hoping to run into some of the Microchip reps I knew from many years past, but unfortunately most of them were not working the booth when I was there. I did discover a great sensor though, using a Microchip PIC as the interface.

TAOS, Inc., was sharing the booth with Microchip and demonstrating an optical sensor that could read a black on clear disk similar to what many hobbyists use on the wheels of their robots (see Figure 2). The big difference was the sensor could read to a resolution of up to 256 positions for every revolution. They were showing this off as a possible steering column sensor as shown in Figure 3. The rotating disk has black lines of varying width, which the sensor could sense. This allowed the setup to determine exactly what rotational position the disk was at. This is something needed for a steering sensor; maybe a robot could also benefit.

Infrared Night Vision

A new entrant at Convergence was BAE Systems showing off their infrared camera technology. All of its current applications are in the defense industry, but they were trying to determine if the automotive world had any application opportunities. The company claimed to have one of the only pure IR cameras available. Night vision was the application they were trying to sell. Maybe this will be coming to a Hummer off-road vehicle someday (Hummers got their start in the military).

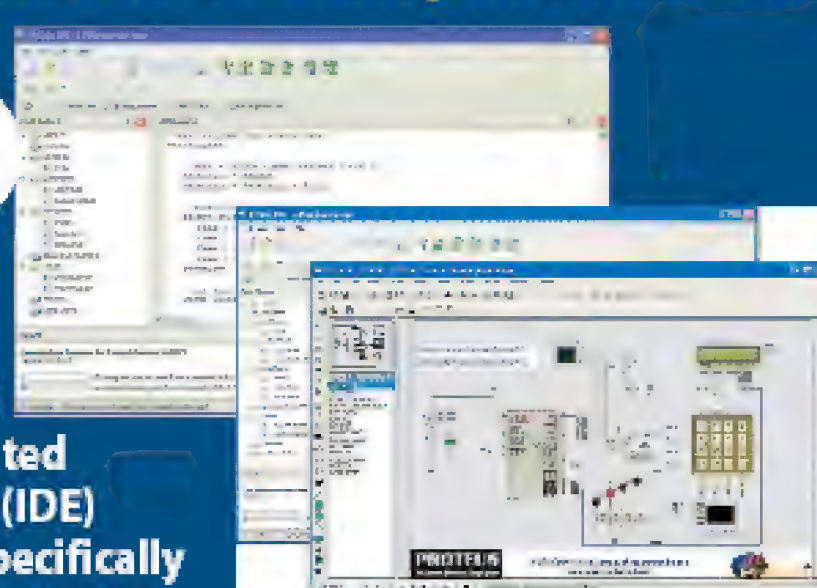
In-Vehicle Displays

We've already seen the in-vehicle entertainment systems become popular with families. Parents can keep the kids quiet in the back seat by playing videos or DVDs on the in-vehicle drop-down LCD display. What Convergence offered were the next generations of this. Texas Instruments had an automotive interior setup with a central PC control and display that made the driver seat feel like the cockpit of an airplane. The headrests of both front seats had separate LCD displays for the passengers in the back seat to view. Each display could have a separate movie or one could even have a video game displayed. This allows children to have their own movie or game with separate wireless headsets making it all work.

The setup also had video cameras at the front and rear of the vehicle, which could be displayed on the front seat screen. The navigation system could be displayed on any screen allowing the children to see for themselves "are we there yet?" All this was selectable from a central menu screen. This actually wasn't that advanced of a setup, as most of this is available in the marketplace now, but this

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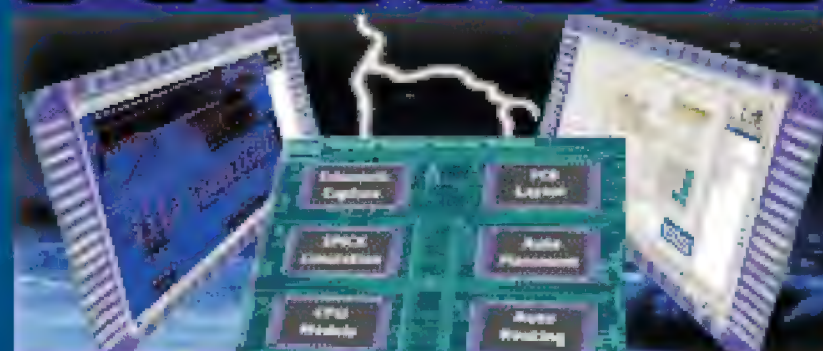
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CONVERGENCE 2004

was the first time I had seen it all packaged together in one control panel.

Microsoft took the whole concept a large step further by installing a huge display in the back of a Hummer. They had Xbox games on it so it was popular with some of the kids that were visiting the Convergence show as a field trip.

Non-Automotive

After a while, I discovered a small golf driving range set up in the middle of the Convergence show. I know many automotive business decisions are made on the golf course, but this still seemed out of place. As it turns out, it had nothing to do with automotive electronics. The company Varta Battery had invited Smart Swing (smartswinggolf.com) to show off their golf swing analyzer, which ran on a Varta battery. The club had a long and thin circuit board with numerous sensors and a TI micro at its core. The club would store data when someone swung and hit a ball into the net. The golf pro at the booth would then plug the club into his laptop and get a full analysis of the swing. I didn't get to try it out since the line was long and appeared to be one of the most popular displays at Convergence.

LIN Bus

I visited the Freescale booth and saw an LIN bus (Local Interconnect Network) demonstration. This simple network architecture is rapidly moving through the automotive world. High speed and low speed CANs (Controller Area Network) are popular, but for low speed, low cost applications the LIN bus appears to be the solution that will also work as a sub-bus network to CAN.

LIN is typically used as an in-vehicle communication and networking serial bus between intelligent sensors and actuators operating at 12 volts. Other automotive applications include air conditioning systems, doors, seats, column, climate control, switch panel, intelligent wipers, and sunroof actuators. If you aren't familiar with it, the LIN bus is a lower speed communication protocol (maximum 19200 baud) that can send or receive full eight-byte commands every 10 milliseconds. The LIN bus does not need to resolve bus collisions because only one message is allowed on the bus at a time.

Freescale had the LIN running a seat set up with several small modules distributed through the seat structure. Each module controlled a feature of the seat including the motors that positioned the seat and lumbar pumps. LIN is currently available on many off-the-shelf micros from Freescale and Microchip. This may become a favorite for robot builders who want to control a complex system.

Panel Discussions

I attended some of the presentations including the main one with Dr. Gerhard Schmidt of Ford Motor Company who was the Convergence 2004 Chairman. It was an interesting presentation from Gerhard and other leaders in automotive management. Their presentations focused on collision avoidance and sensors that will apply the brakes for collision avoidance. They also presented the status of research regarding driver distractions from cell phone use and in-car entertainment systems, like the TI display mentioned earlier. There were a few demonstrations of this on the Convergence show floor, but I expect more in the future as technical presentations tend to lead future show demonstrations as the technology evolves and becomes more affordable.

Wrap Up

Overall, the show was very interesting and I ran into many friends I hadn't seen in years. Some had changed jobs and others had moved up the corporate ladder. I get more inside scoop from these discussions than anything a show could demonstrate and to me, that's the best part of Convergence. If you want to meet some of the electronic decision makers of the automotive electronics industry, then be sure to mark Convergence on your calendar. **NV**

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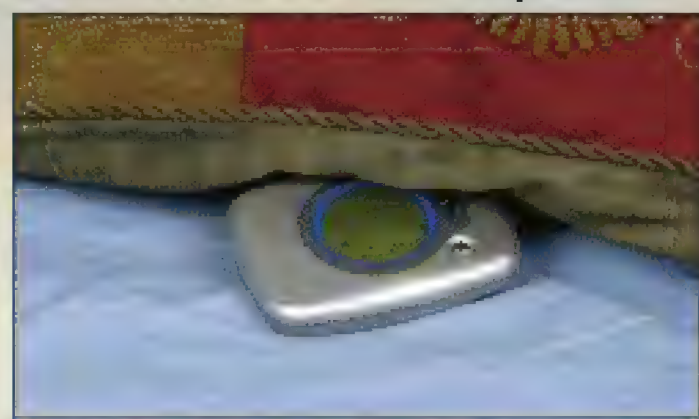
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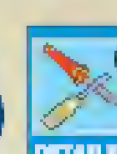
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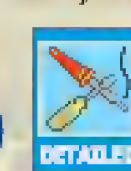


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EXCELLENT CIRCUITS WITH EXCEL

Using Spreadsheets for Digital Circuits

BY PETER STARK

Nuts & Volts Magazine recently had two articles about linear-feedback shift registers, which are shift registers with some of their outputs fed back to the input for generating cyclic redundancy check (CRC) bits or random numbers. Short of actually building these (and other digital) circuits, it's sometimes hard to check that they do what they claim to do. Here is an interesting and simple technique for simulating these circuits on a computer using a spreadsheet program.

It doesn't have to be an expensive or powerful spreadsheet program. For the examples below, I will use Excel, but sometimes old versions of Lotus 123 or shareware programs like As-Easy-As work even better.

The Inverter

Figure 1 shows the basic idea. Looking at an inverter — such as a 7404 — in the TTL manual, you'll often see the inputs and outputs labelled as *In* and *Out*, or perhaps *A* and *B*. But simply label them *A1* and *B1*, and right away, you get the idea: Just use cell *A1* in the spreadsheet for the input and cell *B1* for the output. There's nothing magic about these two cells, as you could use any two cells in the spreadsheet. Now all you have to do is put the

right formula into cell *B1*, so it's always the opposite of *A1*, and you're done.



FIGURE 1. A simple inverter.

For the inverter in Figure 1, if the input is a 0, then the output is a 1, and if the input is 1, then the output is 0 (you have to use 0 and 1, because it won't work if you try to use H and L or True and False instead). There are two ways to do this. The simplest is to write this as the simple formula:

$$\text{Output} = 1 - \text{Input}$$

In other words, in the spreadsheet, cell *B1* should be equal to one minus whatever is in cell *A1*: 1 minus 0 is 1, whereas 1 minus 1 is 0. The formula then becomes:

$$B1 = 1 - A1$$

In Excel, you'd type `=1-A1` into cell *B1* (with the equal sign); whereas, in most other spreadsheets, it would be just `1-A1`. Make sure to check the exact format for whichever spreadsheet you are using. Another way is to use the spreadsheet's IF function, like this:

$$B1 = \text{IF}(A1 = 0, 1, 0)$$

The parentheses contain three arguments: a test, what to do if the test is correct, and what to do if it isn't.

In this case, it says, "if $A1=0$, then make this cell equal to 1, otherwise make it 0." For obvious reasons, I prefer

to use the "one minus" approach.

Figure 2 shows some other simple gates, but let's do them one at a time.

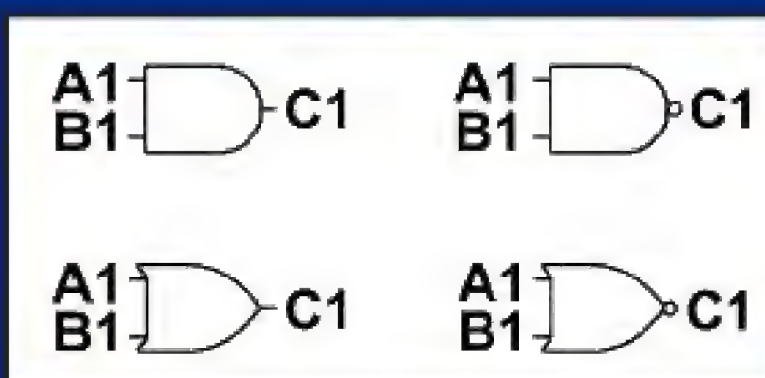


FIGURE 2. Simple digital gates.

The AND Gate

A1	B1	C1
0	0	0
0	1	0
1	0	0
1	1	1

TABLE 1

For the AND gate at the top left corner of Figure 2, the truth table (which describes how it works) is shown in Table 1, from which we can see that the output is just the product of the two inputs — a simple multiplication. So, the formula to put into cell *C1* is $A1 \times B1$.

Some spreadsheets actually have functions for doing simple logical operations. Excel insists on using words like TRUE and FALSE, so that is not very useful to us, but 123 and others use ones and zeroes. The corresponding syntax for this formula in 123 and some others would be `+A1#AND#B1`. Don't bother — $A1 \times B1$ is much simpler.

The NAND Gate

In the NAND gate at the top right corner of Figure 2, the output is similar to that of the AND, but inverted. The equation:

$$C1 = 1 - (A1 \times B1)$$

should just about do it, since the "1-" part does the inversion just as in the inverter.

The OR Gate

A1	B1	C1
0	0	0
0	1	1
1	0	1
1	1	1

TABLE 2

The truth table for the OR is shown in Table 2. The easiest way to implement this is with an IF, like this:

$$C1 = \text{IF}(A1 + B1 = 0, 0, 1)$$

which says that if the two inputs add up to zero (which means they are both zero), make the output a 0, otherwise make it a 1.

The NOR Gate

The NOR is just the opposite of an OR gate (Table

3). Here again, the easiest way to do it is to use an IF:

$$C1 = \text{IF}(A1 + B1 = 0, 1, 0)$$

which is the same as the OR, except that it flips the 0 and 1 in the output.

A1	B1	C1
0	0	1
0	1	0
1	0	0
1	1	0

TABLE 3

XOR — The Exclusive OR

Figure 3 shows the Exclusive OR gate, which has the truth table shown in Table 4. The word *exclusive* means that the output is a 1 if either A1 or B1 is 1, but not both.

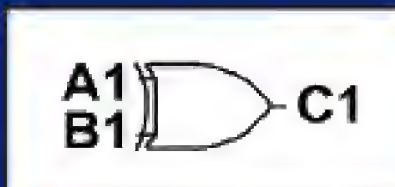


FIGURE 3. The Exclusive OR gate.

If you use the spreadsheet's IF statement, the IF reads:

$$\text{IF}(A1 = B1, 0, 1)$$

which just means that, if the two inputs are the same, then the output is 0; if they are not the same, then the output is 1.

Alternatively, you could also write:

$$C1 = \text{ABS}(A1 - B1)$$

which tells the spreadsheet that the output is the difference between A1 and B1; in case A1-B1 is -1, then the ABS function just changes it into +1.

A1	B1	C1
0	0	0
0	1	1
1	0	1
1	1	0

TABLE 4

Handling Flip-Flops

Flip-flops are interesting because they create some special problems that require unique solutions.

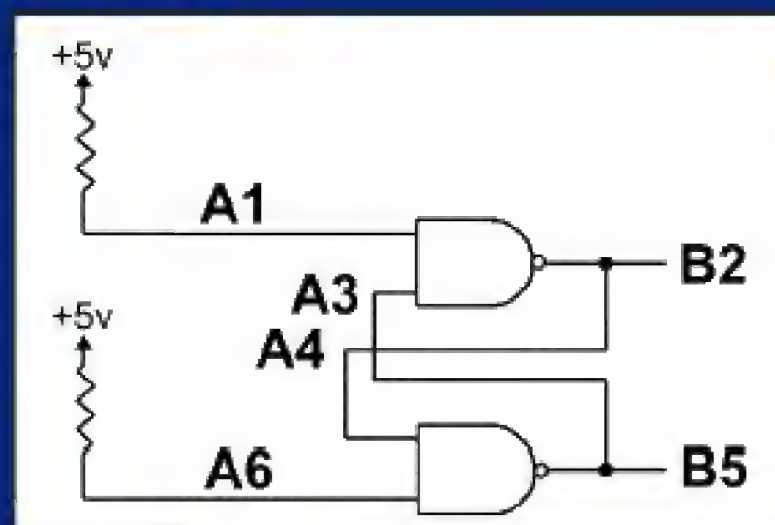


FIGURE 4. Flip-flop made of gates.

Figure 4 shows a simple flip-flop made from two NAND gates. As you know, flip-flops have two outputs, normally labelled Q and Q' (Q' is pronounced Q *not* or *not* Q), which are always opposites of each other. We say that the flip-flop is set if Q is a 1 (while Q' is 0), and the flip-flop is reset if Q is a 0 (while Q' is a 1). If B2 is Q and B5 is Q' in Figure 4, then we can set the flip-flop by temporarily grounding input A1 or reset it by

temporarily grounding input A6. (The two resistors make both inputs normally 1.)

Figure 5 shows the spreadsheet for this circuit as it would look in Excel; on the left are the formulas (Excel shows them when you press CTRL and ` (the reverse apostrophe at the top left of the keyboard), while on the right, it shows what happens.

	A	B		A	B
1	1		1	1	
2		=1-A1*A3	2		1
3	=B5		3		0
4	=B2		4		1
5		=1-A4*A6	5		0
6	1		6	1	

FIGURE 5. Excel spreadsheet for the flip-flop of Figure 4.

The formulas at the left of Figure 5 follow the circuit almost exactly. For example, cells A1 and A6 are both equal to 1, cell B2 is the NAND of cells A1 and A3, and so on. The problem shows up on the right, so Excel inserts a bunch of arrows linking the cells.

The catch is that the circuit uses circular reasoning: A3 depends on B2, which depends on A4, which depends on B5, which depends on A3, and so on. The actual outputs (i.e., whether the flip-flop is set or

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reset) depend on timing and what happened most recently.

Excel doesn't know what to do with this. It turns out that Excel is too *smart*, as older spreadsheets, such as 123, will do what you want as long as you press the "recalculate" key a few times each time you change an input, whereas Excel won't. To handle this, we have to bring time into the spreadsheet — think of *before* and *after*. Common JK or Type D flip-flops have a clock input. Think of the inputs as they existed *before* the clock pulse and the outputs as they exist *after* the clock pulse. The trick for handling flip-flops in a spreadsheet is to bring in time by using the sheet's rows. For example, if Row 1 describes things before a clock pulse, then Row 2 describes things after it. And if there is another clock pulse afterward, then Row 3 describes what happens after that, and so on.

In other words, time goes down in the sheet.

Mod 3 Counter

The best way to show this is with an example. Figure 6 shows a synchronous mod-3 counter that counts 0...1...2...0...1...2... and so on. At any instant of time, the flip-flops get certain inputs and provide certain outputs, but nothing happens until a clock pulse arrives. Let's see how this is done.

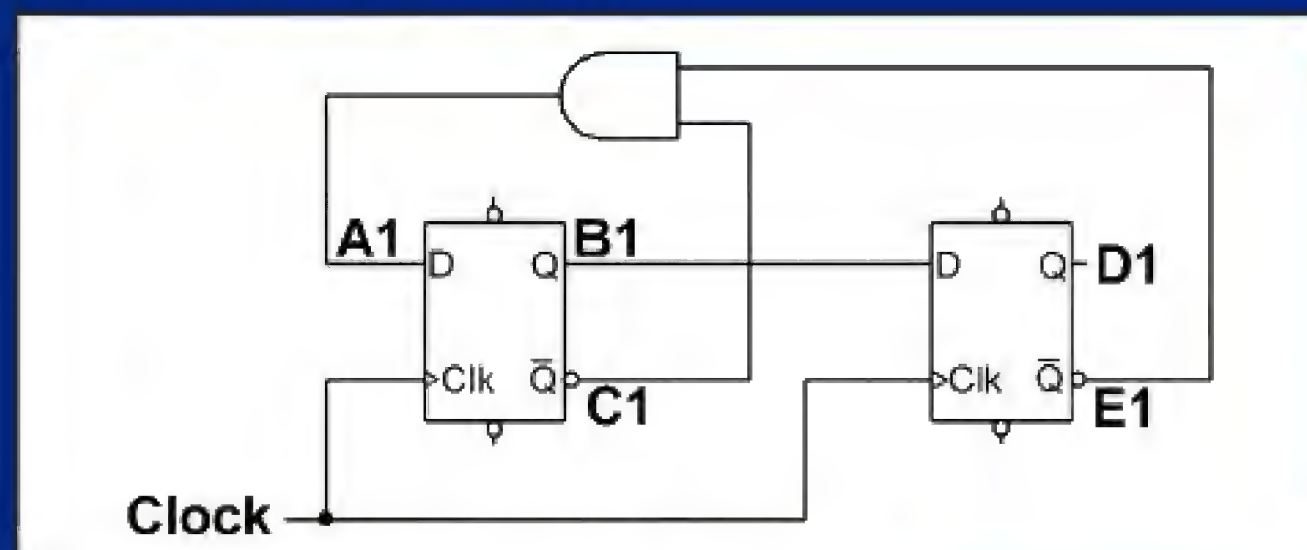


FIGURE 6. Mod-3 synchronous counter.

Look at Figure 7 as we fill in the spreadsheet formulas in the following sequence:

	A	B	C	D	E		A	B	C	D	E
1	=C1*E1	0	=1-B1	0	=1-D1	1	1	0	1	0	1
2	=C2*E2	=A1	=1-B2	=B1	=1-D2	2	0	1	0	0	1
3	=C3*E3	=A2	=1-B3	=B2	=1-D3	3	0	0	1	1	0
4	=C4*E4	=A3	=1-B4	=B3	=1-D4	4	1	0	1	0	1
5	=C5*E5	=A4	=1-B5	=B4	=1-D5	5	0	1	0	0	1
6	=C6*E6	=A5	=1-B6	=B5	=1-D6	6	0	0	1	1	0
7	=C7*E7	=A6	=1-B7	=B6	=1-D7	7	1	0	1	0	1
8	=C8*E8	=A7	=1-B8	=B7	=1-D8	8	0	1	0	0	1

FIGURE 7. Spreadsheet for the mod-3 counter of Figure 6.

To begin, assume that the two flip-flops both start at the reset. Thus, the two Q outputs should be zero, while the two Q' should be their opposites. Thus we fill in:

$$\begin{aligned} B1 &= 0 \\ C1 &= 1 - B1 \\ D1 &= 0 \\ E1 &= 1 - D1 \end{aligned}$$

Next, the D input into the first flip-flop is just C1 and E1 ANDed together, so:

$$A1 = C1 \times E1$$

The top row of the sheet is now complete; it describes the starting, or initial, conditions. Let's now assume that a clock pulse comes in. Row 1 describes the situation *before* the clock pulse, so let's use Row 2 to describe the signals *after* the clock pulse.

At a clock pulse, the D input into a flip-flop determines whether the flip-flop will set or reset; that is, the Q output *after* the clock (in cell B2) will be the same as the D was *before* the clock (in cell A1). The same occurs with the second flip-flop, so we fill in:

$$\begin{aligned} B2 &= A1 \\ D2 &= B1 \end{aligned}$$

At any time, the Q' outputs will still be the opposites of Q, so we can either write:

$$\begin{aligned} C2 &= 1 - B2 \\ E2 &= 1 - D2 \end{aligned}$$

or else just copy the C and E columns all the way down the sheet (and let the spreadsheet update the row numbers). Finally, the output of the gate (and D input to the first flip-flop) is still the ANDed signal from Columns C and E, so we can either write:

$$A2 = C2 \times E2$$

or else again just copy the A column down the sheet.

At this point we're almost done. The second row is finished, and now all we have to do is copy the remaining entries from Row 2 down as far as you want to go.

The results are as shown in Figure 7. To interpret it, look at the B and D columns; these are the two Q outputs from the flip-flops. Column D is most significant while B is least, so we see that the counter outputs are:

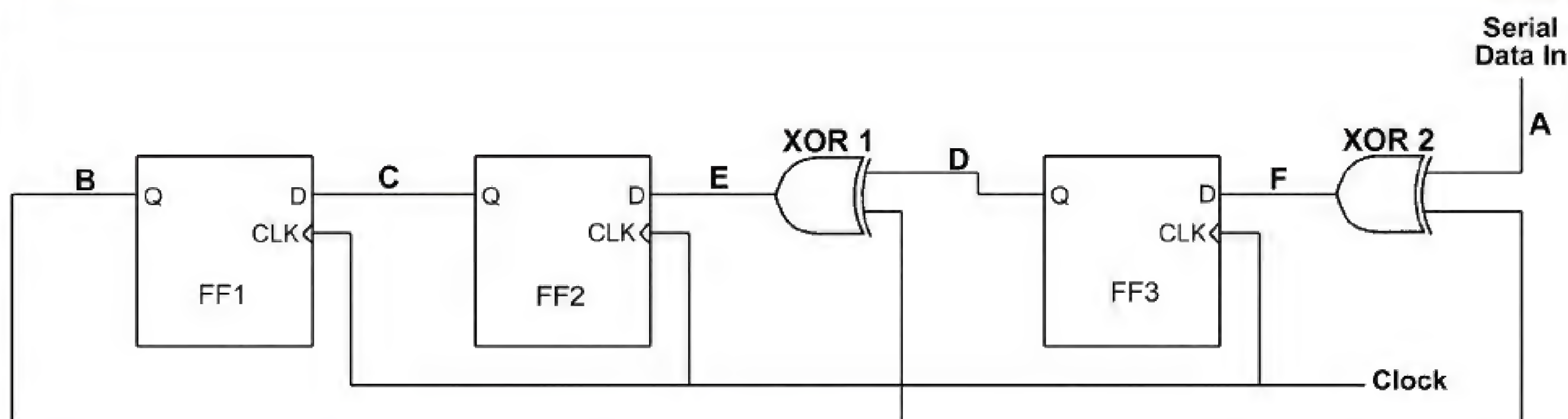


FIGURE 8. The CRC circuit from the July 2004 issue of *Nuts & Volts*.

00 = 0
01 = 1
10 = 2
00 = 0
01 = 1
... and so on.

The CRC Generator

Now that you've gotten the idea, let's apply the material to two real-world problems. The first is a CRC generator which appeared in the July 2004 issue of *Nuts & Volts* in an article by James Antonakos on error detection in digital data. The circuit, shown in Figure 8, uses a shift register with its output fed back into the inputs through two XOR gates. Figure 9 shows the resulting spreadsheet, with the formulas on the left and actual results on the right. The letters A through F in Figure 8 tell us which column of the sheet has that signal.

Rather than explain every cell of the sheet, let's explain what the circuit does. The general idea is this: When digital data is sent from one place to another, a CRC generator is used at the sending end to generate a check number, which is then attached to the end of the outgoing data. At the receiving end, an identical CRC generator gets the data plus the CRC check digits from the sender and tests whether there are any errors. If there are no errors, the receiver's CRC circuit outputs all zeroes; if the output is non-zero, then there was an error.

Let's assume that the outgoing data is the eight-bit number 10101100, and that the CRC check number will consist of three bits. The sender starts with the circuit of Figure 8, and the initial condition that all three flip-flops are reset to 000; this is the 000 in cells B1 through D1.

In order to generate the three-bit CRC number, the

sender appends an extra three 000 bits to the end of the data stream and sends it into the input labeled SERIAL DATA IN of Figure 8 in its own CRC generator. This string of 10101100000 (a total of 11 bits) appears in Column A of the spreadsheet. There is a clock pulse after each input bit, which brings us down one row of the spreadsheet.

At each row, the spreadsheet calculates the outputs

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	A	B	C	D	E	F
1	1	0	0	0	=ABS(D1-B1)	=ABS(A1-B1)
2	0	=C1	=E1	=F1	=ABS(D2-B2)	=ABS(A2-B2)
3	1	=C2	=E2	=F2	=ABS(D3-B3)	=ABS(A3-B3)
4	0	=C3	=E3	=F3	=ABS(D4-B4)	=ABS(A4-B4)
5	1	=C4	=E4	=F4	=ABS(D5-B5)	=ABS(A5-B5)
6	1	=C5	=E5	=F5	=ABS(D6-B6)	=ABS(A6-B6)
7	0	=C6	=E6	=F6	=ABS(D7-B7)	=ABS(A7-B7)
8	0	=C7	=E7	=F7	=ABS(D8-B8)	=ABS(A8-B8)
9	0	=C8	=E8	=F8	=ABS(D9-B9)	=ABS(A9-B9)
10	0	=C9	=E9	=F9	=ABS(D10-B10)	=ABS(A10-B10)
11	0	=C10	=E10	=F10	=ABS(D11-B11)	=ABS(A11-B11)
12		=C11	=E11	=F11		
13						
14	Data	FF1	FF2	FF3	XOR1	XOR2

	A	B	C	D	E	F
1	1	0	0	0	0	1
2	0	0	0	1	1	0
3	1	0	1	0	0	1
4	0	1	0	1	0	1
5	1	0	0	1	1	1
6	1	0	1	1	1	1
7	0	1	1	1	0	1
8	0	1	0	1	0	1
9	0	0	0	1	1	0
10	0	0	1	0	0	0
11	0	1	0	0	1	1
12		0	1	1		
13						
14	Data	FF1	FF2	FF3	XOR1	XOR2

FIGURE 9. The spreadsheet for the CRC circuit of Figure 8.

of the three flip-flops (Columns B through D) and the two XOR gates (Columns E and F). These signals determine what will happen in the next row, after the clock pulse.

At the very end, whatever is left in the three flip-flops (in Row 12) is the CRC number which is appended to the outgoing data. In this particular case, the CRC check number is 011. So, the actual data going from the sender to the receiver will be the original data 10101100, plus the extra 011 from its own CRC circuit. Thus, the sender's CRC circuit gets the data, plus three zeroes, whereas the receiver's CRC circuit gets the data, plus 011 (assuming there were no errors).

Now, let's assume that the receiver has the exact same CRC circuit, so we can use the same spreadsheet as before, with one change. Whereas the bottom three bits in the A column of the sender were 000, in the receiver they will be 011. Try it in your spreadsheet: Change the 000 in cells A9 through A11 to 011 and the three bits in Row 12 become 000, signalling that no error occurred.

Now try changing one or more of the bits in column A to simulate an error in transmission; you will see that the last row is no longer 000. This tells the receiver that there was a transmission error in the data.

A Random-Number Generator

Figure 10 shows a random-number generator taken from an article in the August 2004 *Nuts & Volts*.

Starting with an initial value called the *seed*, the circuit is supposed to cycle through some sequence of operations and output a string of random eight-bit numbers. These numbers are the contents of the eight flip-flops after

every clock pulse.

A fairly simple, yet useful, definition of "random" would be that a number is random if even an intelligent observer, knowing the past numbers in the sequence, can't guess what the next number will be.

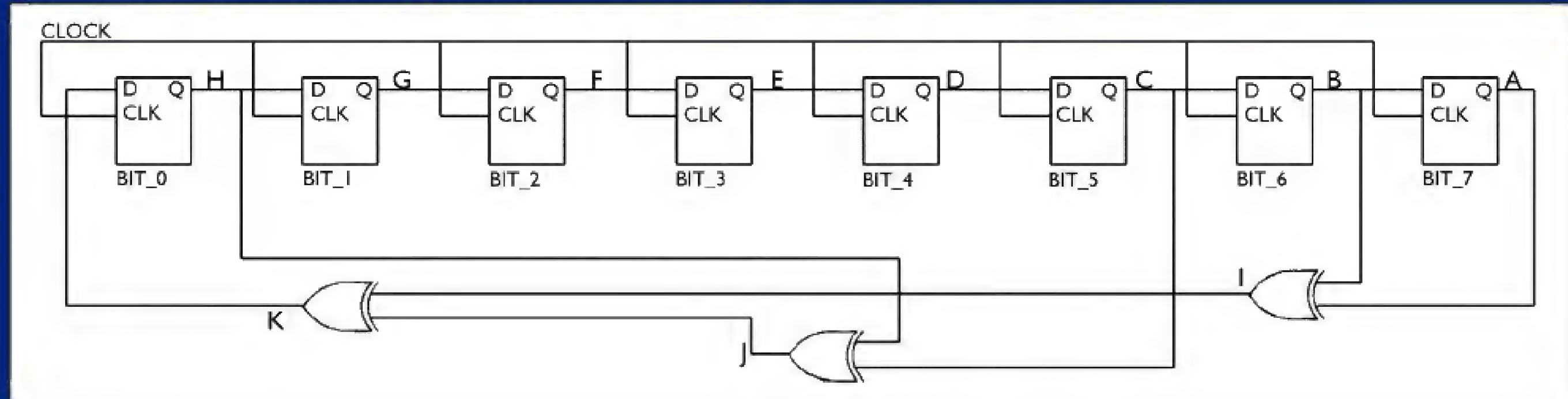
The numbers output by most random-number generators are actually called *pseudo-random* because they are not truly random — they only look it. They are predictable if you know the circuit or process that produced them. Still, for many applications, pseudo-random numbers are good enough.

The circuit is somewhat similar to the CRC circuit — it also has a shift register with some XOR gates to feed its outputs back into the input. But this time, there is only a clock input and no data input. As before, I've added letters to the diagram to show which signal will be in which column of the spreadsheet.

Figures 11 and 12 show the formulas and results of this spreadsheet (I added an extra column at the right in Figure 12 that converts the eight-bit binary output in Columns A through H into hexadecimal).

The initial seed is what would be in the flip-flops at the start. It is at the top in cells A1 through H1. Starting with any seed, the circuit should produce 255 numbers before it starts to repeat itself. In order to get the same sequence of numbers as the *Nuts & Volts* article, I used

FIGURE 10. Random number generator from the August 2004 issue of *Nuts & Volts*.



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	A	B	C	D	E	F	G	H	I	J	K
1	1	0	0	0	0	0	0	1	=ABS(B1-A1)	=ABS(C1-H1)	=ABS(I1-J1)
2	=B1	=C1	=D1	=E1	=F1	=G1	=H1	=K1	=ABS(B2-A2)	=ABS(C2-H2)	=ABS(I2-J2)
3	=B2	=C2	=D2	=E2	=F2	=G2	=H2	=K2	=ABS(B3-A3)	=ABS(C3-H3)	=ABS(I3-J3)
4	=B3	=C3	=D3	=E3	=F3	=G3	=H3	=K3	=ABS(B4-A4)	=ABS(C4-H4)	=ABS(I4-J4)
5	=B4	=C4	=D4	=E4	=F4	=G4	=H4	=K4	=ABS(B5-A5)	=ABS(C5-H5)	=ABS(I5-J5)
6	=B5	=C5	=D5	=E5	=F5	=G5	=H5	=K5	=ABS(B6-A6)	=ABS(C6-H6)	=ABS(I6-J6)
7	=B6	=C6	=D6	=E6	=F6	=G6	=H6	=K6	=ABS(B7-A7)	=ABS(C7-H7)	=ABS(I7-J7)
8	=B7	=C7	=D7	=E7	=F7	=G7	=H7	=K7	=ABS(B8-A8)	=ABS(C8-H8)	=ABS(I8-J8)
9	=B8	=C8	=D8	=E8	=F8	=G8	=H8	=K8	=ABS(B9-A9)	=ABS(C9-H9)	=ABS(I9-J9)
FF7 FF6 FF5 FF4 FF3 FF2 FF1 FF0 XOR3									XOR2	XOR1	

FIGURE 11. The “random” number generator formulas.

an initial seed of 10000001, which is hexadecimal 81. Using this as a starting value, the circuit outputs the following sequence (starting with Row 2):

00000010 = hex 02
 00000100 = hex 04
 00001000 = hex 08
 00010000 = hex 10
 00100000 = hex 20
 01000001 = hex 41
 10000010 = hex 82
 00000101 = hex 05

The problem is that these numbers are not very random at all — the bits in consecutive numbers just shift to the left, with an occasional new “1” appearing at the right end. Hence, if you know the previous numbers, you have a slightly better-than 50 percent chance of guessing the next number. You always know the first seven bits of it, and so all you need to do is take a guess as to whether the last bit will be a zero or a one.

But that’s another story. The point is that using a

spreadsheet to analyze this circuit and looking at the bits output at each clock pulse is very instructive. In this case, it allows us to see that the circuit has a defect which would not be very noticeable if we just looked at the hexadecimal output.

One Last Comment

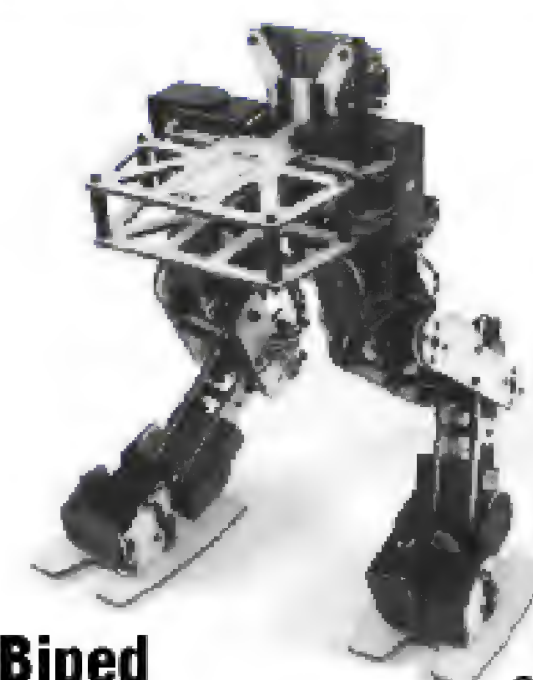
This is a simple and cheap technique. Even though I used Excel in my examples, you can use any of the free or shareware spreadsheet programs out there to do exactly the same thing. No exotic spreadsheet functions are needed. **NV**

	A	B	C	D	E	F	G	H	I	J	K	L
1	1	0	0	0	0	0	0	1	1	1	0	81
2	0	0	0	0	0	0	1	0	0	0	0	2
3	0	0	0	0	0	1	0	0	0	0	0	4
4	0	0	0	0	1	0	0	0	0	0	0	8
5	0	0	0	1	0	0	0	0	0	0	0	10
6	0	0	1	0	0	0	0	0	0	1	1	20
7	0	1	0	0	0	0	0	1	1	1	0	41
8	1	0	0	0	0	0	1	0	1	0	1	82
9	0	0	0	0	0	1	0	1	0	1	1	5
10	0	0	0	0	1	0	1	1	0	1	1	B
11	0	0	0	1	0	1	1	1	0	1	1	17
12	0	0	1	0	1	1	1	1	0	0	0	2F
13	0	1	0	1	1	1	1	0	1	0	1	5E
14	1	0	1	1	1	1	0	1	1	0	1	BD
15	0	1	1	1	1	0	1	1	1	0	1	7B
16	1	1	1	1	0	1	1	1	0	0	0	F7
17	1	1	1	0	1	1	1	0	0	1	1	EE
18	1	1	0	1	1	1	0	1	0	1	1	DD

FIGURE 12. The “random” number generator results.

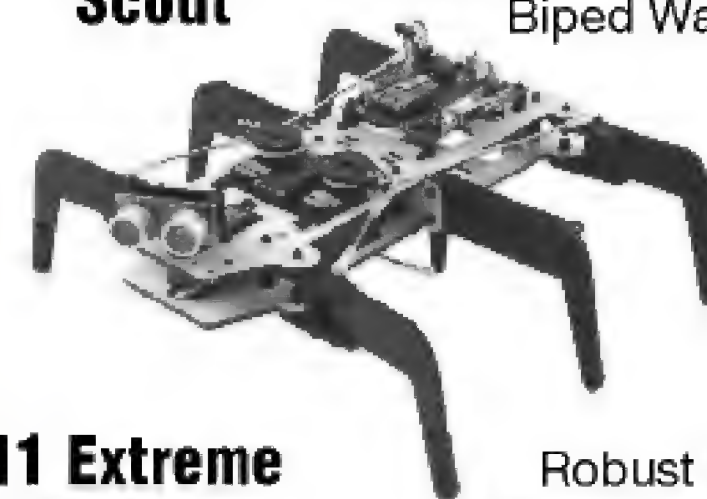
ABOUT THE AUTHOR

Peter Stark is professor of electrical and computer engineering technology at Queensborough Community College, part of the City University of New York. He has been working in engineering and teaching for over 45 years and has written several books, as well as close to a hundred magazine articles. He has a website at www.cloud9.net/~pastark



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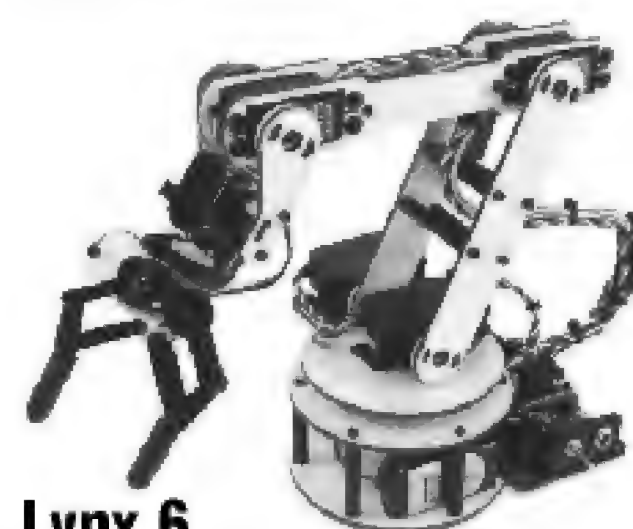
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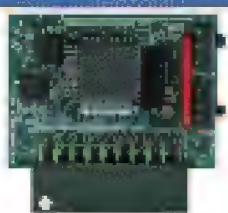
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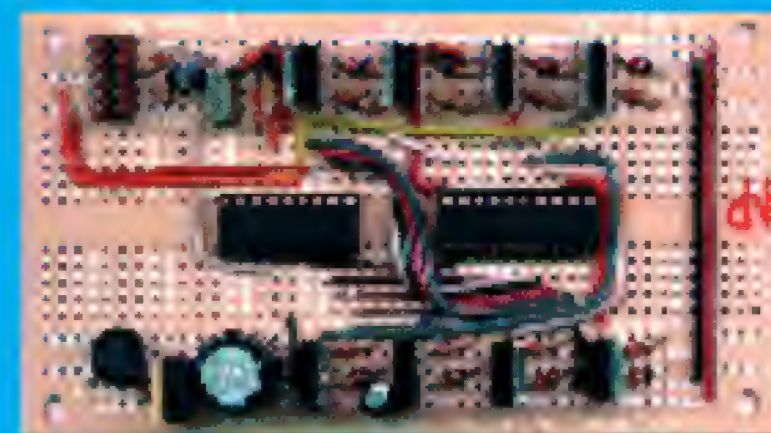
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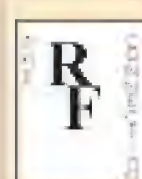
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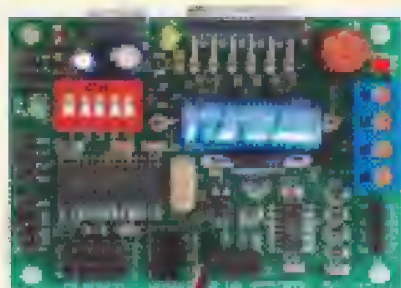
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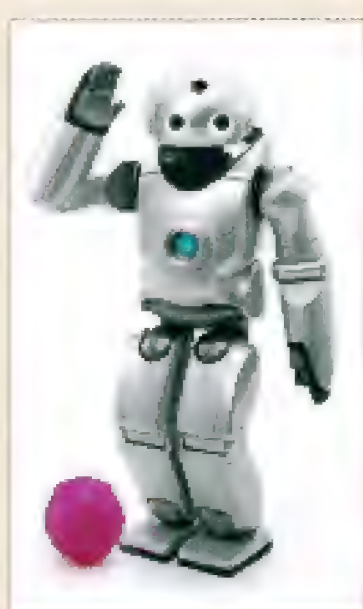
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Robot Goes to Preschool

Qrio, a humanoid robot developed by Sony Intelligence Dynamics Labs, Inc., has been attending a nursery school in California since March to play with children up to two years of age in an experiment to help develop a robot that can "live in harmony with humans in the future."



Qrio spends time each day with more than 10 toddlers at the nursery school located in San Diego. Qrio is always accompanied by a researcher, who is in charge of making sure everything goes smoothly. While the children were at first apprehensive about Qrio, they now dance with it and help it get up when it falls. "The children think of Qrio as a feeble younger brother," researcher Fumihide Tanaka said.

AOL Tags Emergency Alerts as Spam

Emergency managers in Indian River County, Vero Beach, FL — hard-hit by hurricanes last year — thought the best way to get out weather alerts was by email — until they learned that AOL was tagging the messages as spam.

"Because we send out mail in large numbers, it becomes a pattern for spam senders," said Basil Dancy,

a county computer software engineer.

The problem started last year with frequent alerts during an unusually busy hurricane season when four major storms hit Florida, including two — Frances and Jeanne — that swept over Indian River County with winds above 100 mph.

About 4,200 people signed up for the county's email alert service, offering quick alerts on hurricanes, tornadoes, and other weather emergencies.

"In the 16 years I've been in this office, it is the No. 1 thing that best informs the public," said Nathan McCollum, the county's emergency management coordinator.

The county is working with AOL to fix the problem. In the meantime, AOL users are being told to put the county's email account in their computer's address book so their computers know to accept the messages.

Car That Don't Crash

Microsoft Corp. mogul Bill Gates and the leader of Ford Motor Co. have outlined a future in which

software will enable cars to fix themselves and avoid accidents.

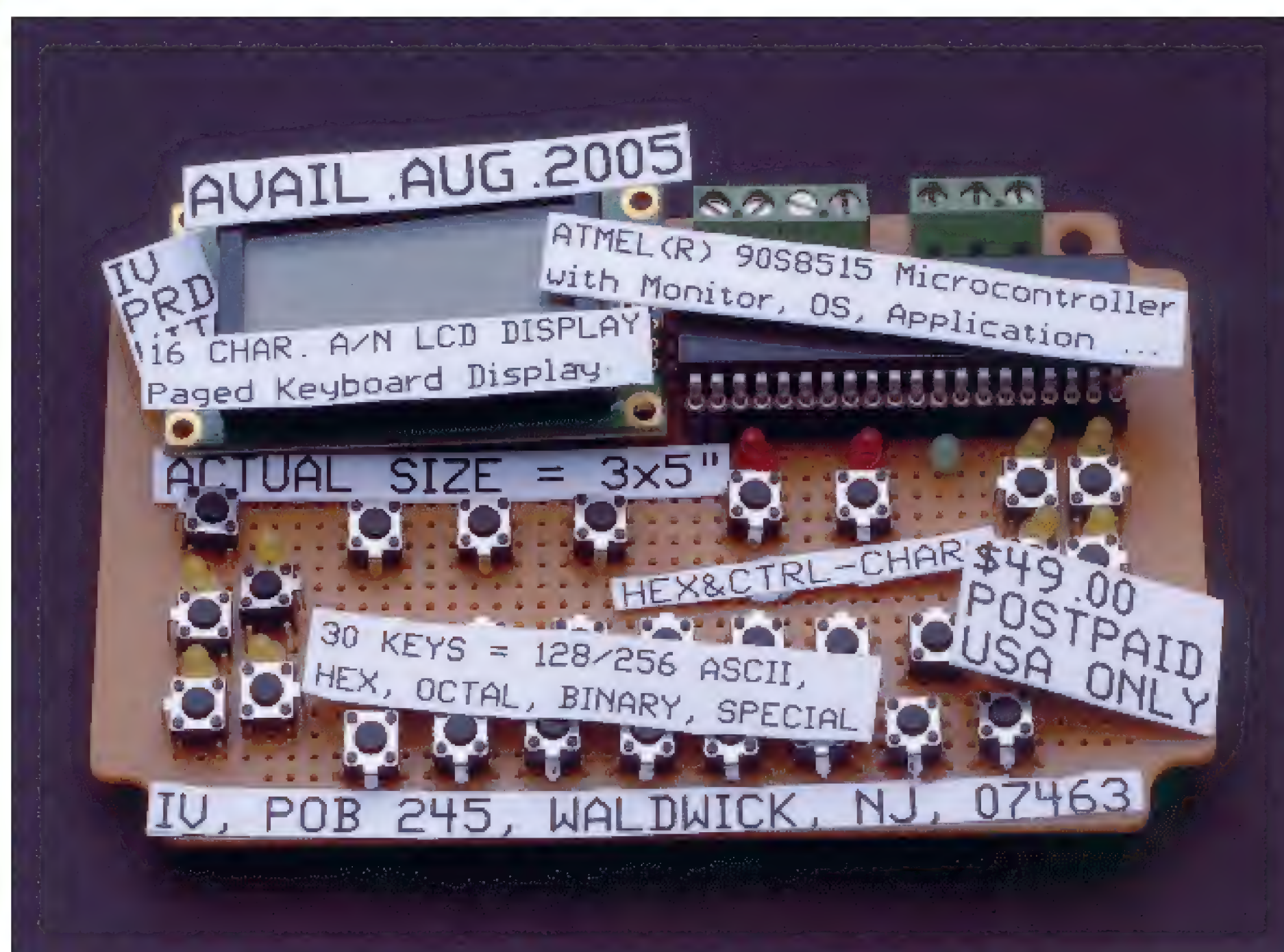
At the recent Microsoft Global Automotive Summit at the automaker's suburban Detroit, MI, campus, Gates and Bill Ford Jr., Ford's chairman and chief executive, said high-definition screens, speech recognition technology, cameras, digital calendars, and navigation equipment with directions and road conditions will set car companies apart from their competitors. Eventually, Gates said, there could be a car that wouldn't let itself crash.

"That absolutely should be the goal," Gates told several hundred participants at the event. "The embrace of technology will be the key for the leaders of the industry."

Microsoft also unveiled its Performance Peak Initiative — a line of computer systems to help the auto industry better coordinate supply chains, streamline design, production and sales, and fill vehicles with computer gadgets.

The company said its technology is currently in 25 vehicle devices from 13 automotive companies.

Microsoft also owns MSN Autos, a vehicle information and buying network.



It's Back ...

Entry Deadline June 13th!

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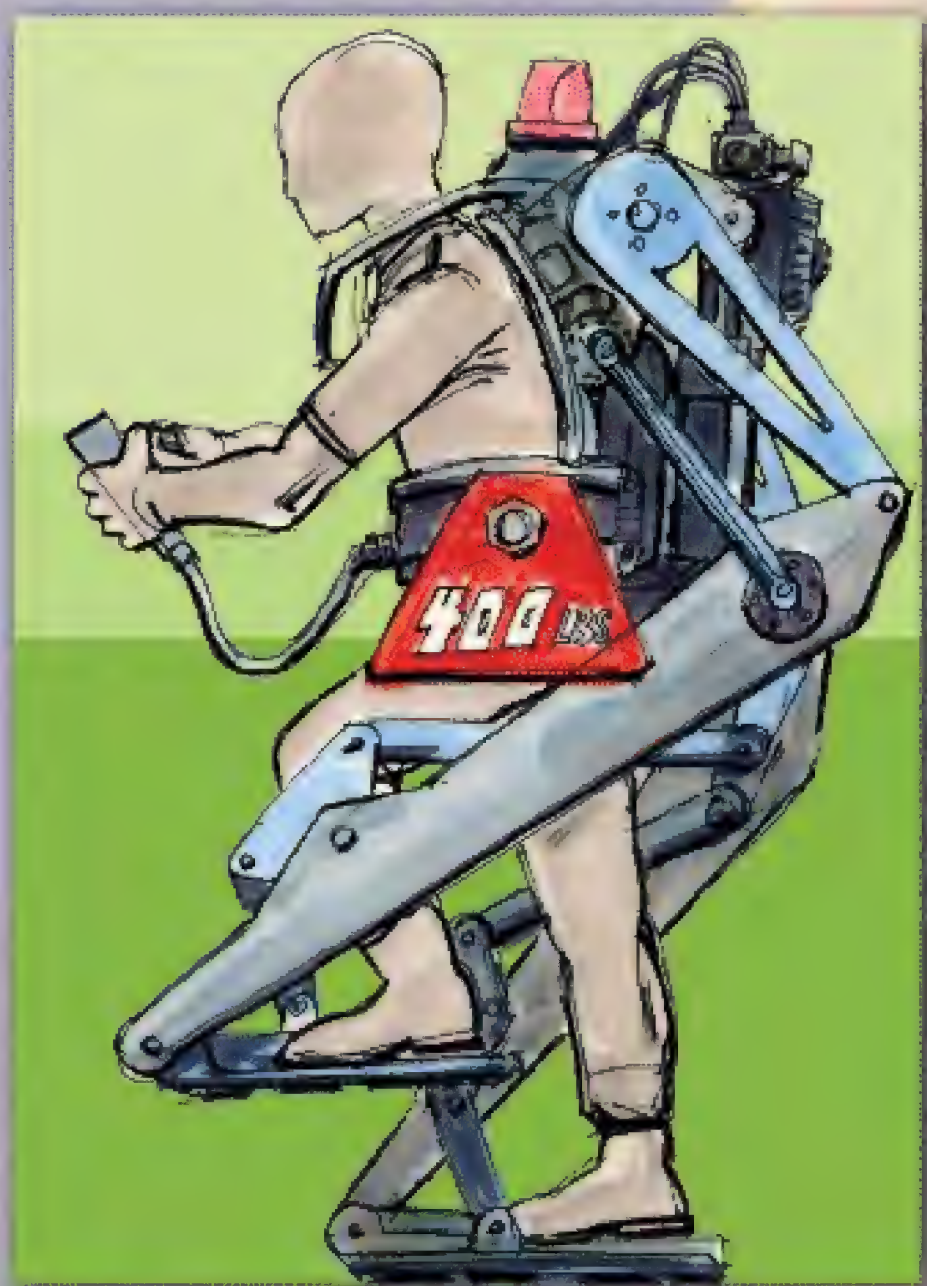
Weightlifting. Ascend stairs in your suit to the lifting platform and lift a load of from 100 to 1,000 lbs* from a squatting position to a height of at least 24 inches*, return the load to the ground in a controlled manner, and descend the stairs. Stair-climbing may be unpowered. The winner is the competitor who lifts the most weight.

CHALLENGE 2:

Dexterity. Stack nine concrete cylinders weighing about 70 pounds each in a 4-3-2 vertical arrangement, but don't knock them over as the pyramid grows! The winner is the competitor who arranges the cylinders in the shortest time.

CHALLENGE 3:

Walking Race. Walk the 100 foot* long U-shaped challenge course, stepping over a small obstacle at the half-way point. The shortest time wins, with a time bonus being granted based on any auxillary load carried. Walking must be powered.



The current rule set is available online at
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The Latest in Networking and Wireless Technologies

Open Communication

Radio Frequency Identification (RFID)

Wireless technology comes in all shapes and sizes these days. Radio Frequency Identification or RFID is one of them. You have probably seen the initials RFID and didn't really know what they meant. Yet, you may already be using it.

If you have a company identification badge where you work and you have to wave it in front of a box to get in, you are using RFID. If you use an E-Z Pass on your windshield to pay your tolls, or use your ExxonMobil SpeedPass to buy gasoline, you are using RFID. If you shop at Walmart, you have experienced RFID. If you are in the military, you may be wearing RFID or using it to keep track of your equipment.

In any case, RFID is an electronic method of identifying objects and things with an electronic code, then transmitting it wirelessly when asked. It is just like the bar code that appears on almost every object we buy and use, but you don't have to have a laser reader to scan it. You can read the RFID code by radio many feet away. Here is an introduction to this rather hot wireless topic of the day.

How Does it Work?

The main component of an RFID system is the tag. Also called a smart card or a transponder, this is a tiny silicon chip containing a small memory containing a unique electronic product code.

The chip is usually bonded to a flat piece of plastic containing a loop antenna. The chip is typically only a few millimeters on a side, but the copper antenna loop on the plastic can be several inches wide. See Figure 1. The tag is then pasted to a box, pallet, carton,

or other object just like a mailing label.

The other part of the system is the reader or interrogator. This is a radio transmitter/receiver designed to interrogate the tag and read its stored code. Figure 2 shows the complete system. Here's what happens.

To read the tag, the transmitter in the reader powers up and transmits a signal to the tag. Unlike standard radio, in RFID, the signal transmitted is not the usual electromagnetic signal. The electromagnetic signal occurs only when it travels more than about one wavelength from the antenna. This is called the far field. At a distance less than one wavelength (λ) where a wavelength is $\lambda = 300/f_{\text{MHz}}$ meters where f_{MHz} is the operating frequency.

The tag only sees the magnetic field from the reader antenna. This is called the near field. In fact, the reader antenna acts like the primary winding of a transformer. The magnetic field it produces cuts across the tag antenna that acts like the secondary winding of a transformer. The voltage induced into the tag antenna is sent to a rectifier and a filter on the tag chip where it develops a low DC voltage that is used to power the circuits in the tag. Neat, huh? The tag doesn't have its own power source. Instead, it uses the RF power from the reader and converts it to DC to operate the circuits.

When the tag powers up, it transmits the special electronic code in the memory back to the reader. The memory is an electrically erasable read-only memory (EEPROM). The code is written into the memory by the manufacturer. The serial data is used to modulate the reader signal.

What the tag does is modify the impedance of the antenna in such a way that the reader detects a loading

and unloading of the circuits. It is the same as putting a heavier load on a transformer and that, in turn, causes a change in the amplitude of the primary signal. The result is a form of amplitude modulation known as amplitude shift keying (ASK). The form of ASK is referred to as backscatter modulation.

Back at the reader, a peak detector — usually a type of voltage-doubling diode rectifier circuit — demodulates the ASK and the slicer shapes it up into a clean serial data signal that is then usually transmitted back to a computer via an RS-232, RS-422, USB, or other interface. The computer then identifies the tag and goes on to perform whatever the application requires.

Some More Technical Details

A major factor in the use of RFID is the frequency of operation. The most common ones are 125 kHz, 13.56 MHz, and 915 MHz. Sometimes 2.4 GHz is used. In any case, these frequencies are those blessed by the Federal Communications Commission

Figure 1. A typical RFID tag for 13.56 MHz. The chip is too small to see, but you can make out the fine copper loop pattern that is the antenna. Courtesy of Texas Instruments.



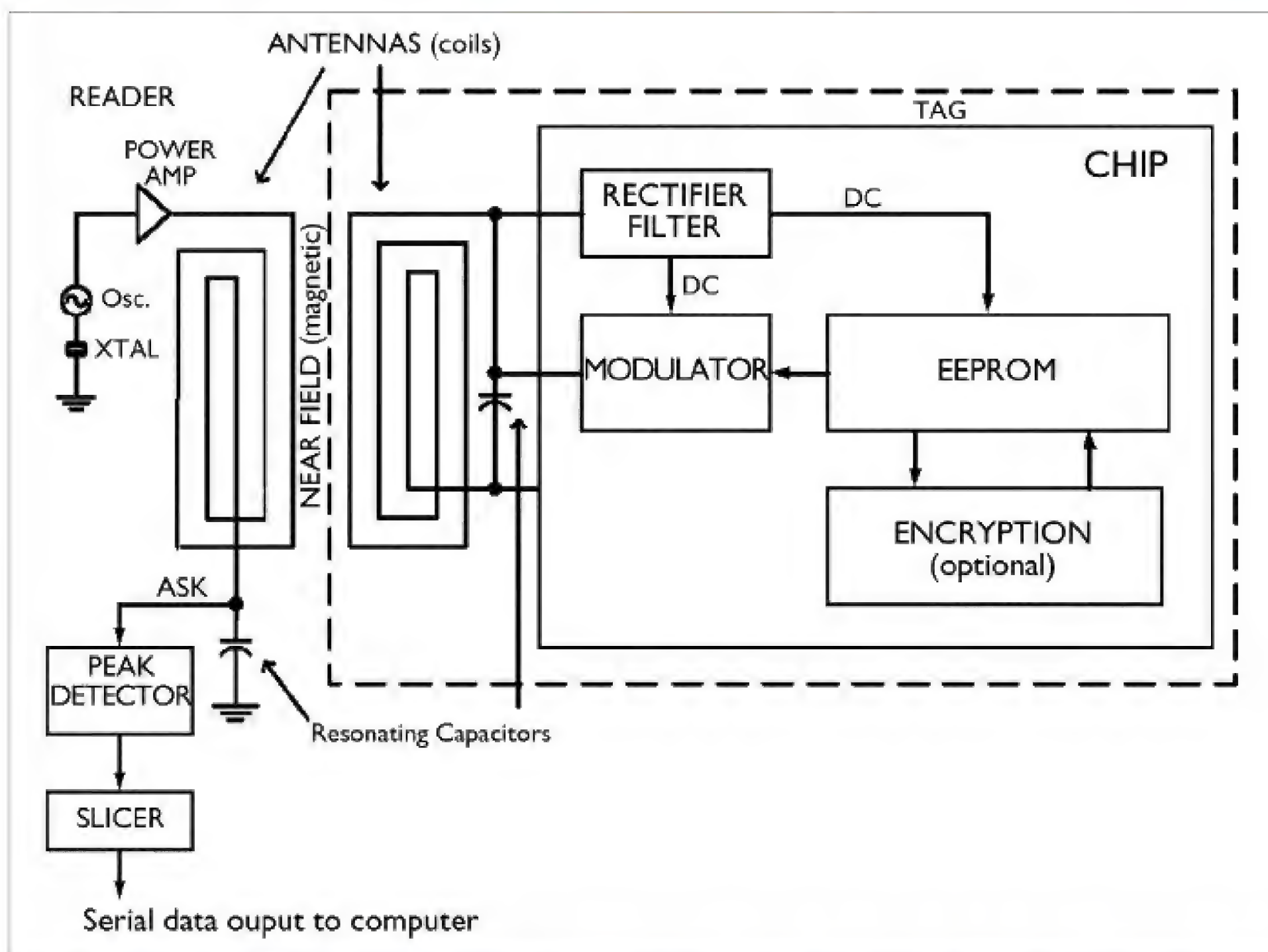


Figure 2. Complete block diagram of a basic RFID system. The reader has an output power of about one watt and is good for up to three feet or so at 13.56 MHz (the most common frequency). The resonating capacitor on the tag is a surface-mount type that is outside the chip. Anti-collision circuits are not shown.

(FCC) for unlicensed uses. These are what are known as the industrial-scientific-medical (ISM) bands and they are covered under the FCC's Part 15 rules and regulations.

The first tags available decades

ago used the 125 kHz frequency. This frequency works best if there is lots of metal nearby or if water is involved. The 125 kHz tags work best on humans and animals because they are mostly made up of water, anyway. Tags

are widely used for animal tracking and are at the heart of tracking the mad cow problem of recent years. The read range at this frequency is pretty short, no more than about 18 inches or so.

The most popular frequency is 13.56 MHz. The tag's antennas can be smaller at this frequency and the read range is much greater — up to three feet or so. The 915 MHz UHF tags give the best reading range of six feet or more. The forthcoming Generation 2 tags use this frequency and can achieve a read range up to 30 feet, in some cases.

Another technical issue is the data rate or the speed with which the data in the tag memory is read out. The low frequency tags have a very low data rate of only a few kilobits per second (kbps). The 13.56 MHz tags have a faster rate in the 50 to 100 kbps. This is usually fast enough, given that the amount of data in the tag is not great — only 64 to 96 bits in the simpler tags. So even at this low speed, the reading seems almost instantaneous to us.

Basically, the higher the operating frequency, the higher the potential data rate. The new UHF tags have a 212 kbps rate and the newer standards call for 424 kbps (and even higher) rate. The higher rates are desirable especially when the reader is trying to read lots of tags in sequence or tags that are together in a batch.

That brings up another issue — tag interference. If a reader tries to read two tags next to one another, both tags power up and try to send data to the reader. The result is interference, read errors, or no read. To prevent this problem, many of the newer tags have an anti-collision feature that prevents this problem.

Different manufacturers handle this in different ways. One tag maker uses a time division multiplexing scheme where each tag responds in its own assigned time slot. Another uses an access method that causes each tag to wait a random length of time before transmitting, which ensures that no two tags transmit at the same time. With anti-collision and high data rate features, readers can read a whole

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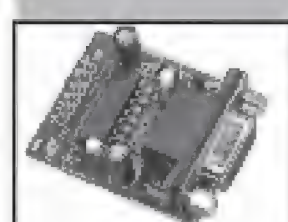
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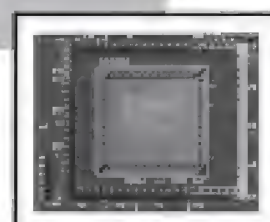
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slew of items together in a pile.

One other feature found on some of the newer tags is security. These tags have encryption built in so that it scrambles the data so that no one else can read and understand it. For most applications, this is not necessary, but when RFID tags find their way into credit cards and passports, we won't want anyone else to hack into the system and steal our ID numbers and use them to charge up our credit cards.

While most RFID tags are passive (no internal power source), active tags containing a battery are also available. These tags are bulkier and more expensive, but with a battery, they can be read at distances up to a couple hundred feet. These are used on the more expensive items to be tagged like big pallets or shipping containers or capital equipment items like trucks or military equipment.

The big issue in getting RFID adopted is tag cost. Bar codes are

super cheap since all you have to do is print them on the package. Passive RFID tags are relatively expensive. Today the cheapest tags are about 25-30 cents. If the item being tagged has a price or value near that, it is probably not worth tagging. Any item with a value of \$10.00 or more can probably stand the extra cost of a tag. The hope is that technology will drive the tag price down to 5-10 cents, but that may never happen. Yet, at 25 cents, lots of items will get tagged.

A Technology Solution Looking for a Problem

RFID is like many electronic products — an answer looking for a



Figure 3. A typical 125 kHz tag used for animal tracking. Courtesy of EM Microelectronic.

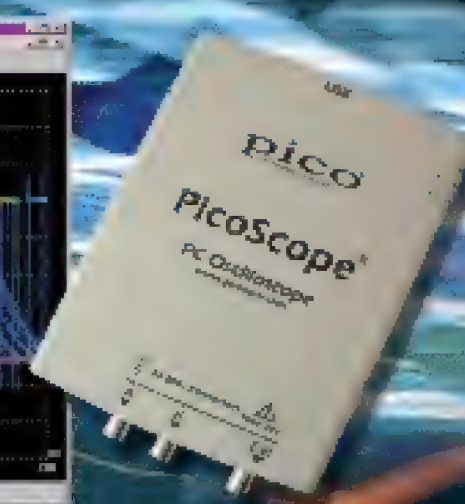
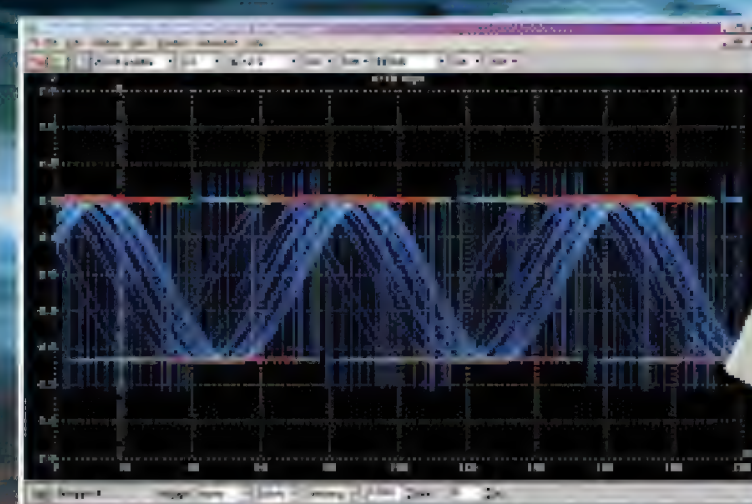
question. Yet, it has found many applications. Probably the most common use is in access and payment applications such as building access, access to parking lots, toll roads, and other for-pay facilities. As mentioned previously, animal tracking is a big one. See Figure 3.

The application with the greatest potential is supply chain manage-

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ment where companies like Walmart, Gillette, Proctor & Gamble, and other big retailers will tag products rather than mark them with bar codes. The big benefit is that the tags can be out-of-sight, but be read anyway. You don't need direct line-of-sight as you do with a bar code laser reader.

Ultimately, the goal is to be able to read an entire basket full of groceries, price them, and charge the buyer's credit card in less than a second. The tags are currently still too expensive for small consumer applications, but putting the tags on cartons, pallets, and whole shipments of products will help track inventory, take inventory, and restock when supplies run low.

RFID is also showing up in manufacturing. Bar codes have been used for years to track work in progress and materials handling. Now, electronic tags are taking their place. These tags can be written to during processes to update them with related status information.

The military is also using RFID. The Department of Defense (DoD) mandated the use of RFID recently to track the tons of materials that go to Afghanistan and Iraq. It makes locating supplies much easier. With a hand-held reader, a soldier can find out which crates contain the new batch of MREs without unpacking everything else. Anyway, you get

the idea.

Even credit cards are getting into the action. Cards with RFID chips are called smart cards and are already popular in Europe. American Express has their high-end Blue card with a chip inside. Soon Visa and MasterCard will follow.

The government will begin putting RFID chips in the new passports starting this year. You should expect states to begin putting them into driver's licenses since that credential is one of our most used forms of identification.

Something to Think About

RFID is one of the fastest-growing, wireless technologies. It is widely used now, but this is just the tip of the iceberg. The interesting thing — or maybe the scariest thing — is that RFID is nearly invisible. We don't readily see it and we may not know when it's being used. The chips will provide speed and convenience in the retail business and automate many things we now do manually.

Are our rights being violated? Maybe, maybe not. How do we feel about it? We'll probably just have to adjust to it whether we want it or not. And isn't that the way it is with most electronic technology we use right now? **NV**

Resources

EM Microelectronic
Manufacturer of tags and equipment.
www.emmicroelectronic.com

EPCGlobal
One of the organizations that develops standards for RFID.
www.epcglobalinc.org

How Stuff Works
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www.howstuffworks.com

Intermec Technologies
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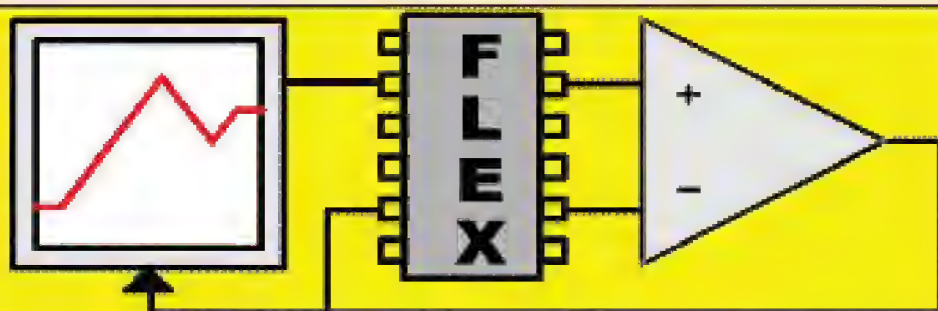
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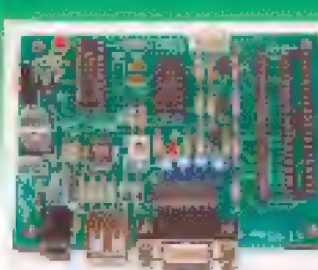
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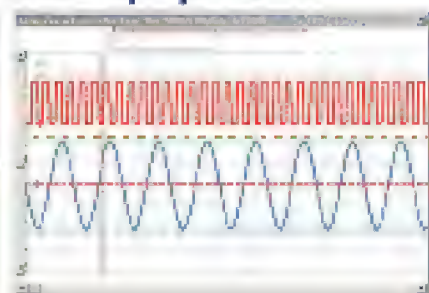
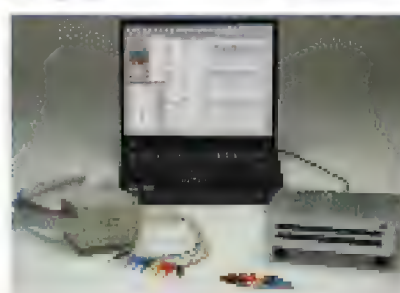
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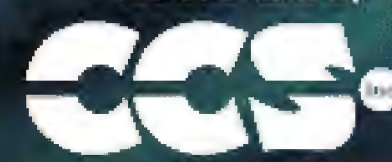


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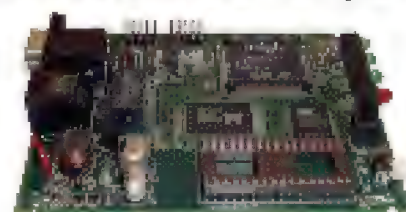
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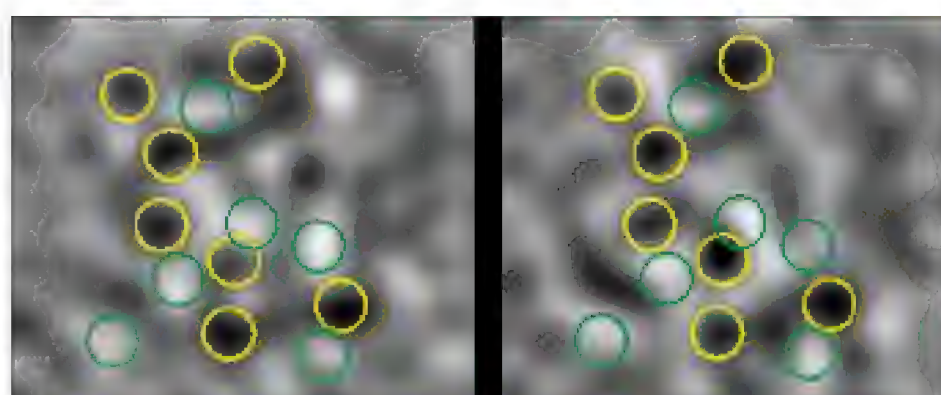
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Tapping Entangled Atoms



Images showing similar noise patterns in entangled atom pairs immediately after being split from the same molecule. Photo courtesy of NIST.

Under certain conditions, the properties of one atom instantaneously affect the properties of its “entangled” mate, even when they are separated by a relatively substantial distance of up to 350 m (approximately five times the diameter of a human hair). Einstein referred to the phenomenon as “spooky action at a distance,” which only coincidentally also describes some creepy Internet relationships. Now, using a technique that measures noise patterns in such atom pairs, physicists at JILA, a joint institute of the National Institute of Standards and Technology (NIST, www.nist.gov) and the University of Colorado at Boulder (www.colorado.edu), can — at least in principle — identify and test the limits of entanglement.

The process produces images from an ultracold cloud of potassium

and has provided the first-ever visual evidence of correlated ultracold atoms. It uses a laser to trap and cool a cloud of about half a million potassium atoms to near absolute zero. Then, a second laser is shined on the atoms, which absorb some of the light, and an image is made of the shadow pattern behind the atoms. The darkest areas have the highest concentrations of atoms that absorb the light. The grainy or dappled pattern of lighter and darker areas represents the so-called “atom shot noise.” One would expect random noise to appear but, in fact, duplicate patterns emerge as shown in the image, thus illustrating entanglement.

The ability to test such basic rules of quantum physics could be helpful, for example, in designing quantum computers that would use properties of neutral atoms as 1s and 0s for data storage and processing. It could also enable scientists to “see” other types of correlations between atoms in “fermionic condensates,” a new quantum state in which thousands of atom pairs behave in unison. It might also be employed in measurement techniques that use beams of entangled atoms.

Brain-to-Computer Interface

In the continuing effort to link the human brain to a computer, a pilot clinical trial of the BrainGate™ neural interface system is being conducted by its creator, Cyberkinetics Neurotechnology Systems, Inc. (www.cyberkineticsinc.com). It is expected that people using the BrainGate system will employ a personal computer as the gateway to a range of self-directed activities. These may extend beyond typical computer functions to include the control of such objects as telephones, televisions, and lights.



Cyberkinetics' BrainGate™ interface may allow severely disabled individuals to control external devices using thoughts. Photo courtesy of Cyberkinetics Neurotechnology Systems, Inc.

The system is based on a technology designed to sense, transmit, analyze, and apply the language of neurons, which is applied to create cursor movement on a PC. Study participants have a sensor attached to the part of the brain that controls movement, and the sensor is connected to a pedestal that is mounted on the skull and protrudes through the skin. A subject attempts to control the cursor with his thoughts. The company is also developing the system to potentially provide limb movement to people with severe motor disabilities, but this is currently at the research stage. In addition, Cyberkinetics is developing products for robotic control, such as a thought-controlled wheelchair. At present, it is not approved for sale to the public, so you'll have to keep using the TV remote for the time being.

Computers and Networking

Dual-Core Processors Debut

By the time you read this, at least a few devices will be on the market that use the new dual-core processors from AMD (www.amd.com) and Intel (www.intel.com). Both incorporate two processors and

L2 caches on one silicon chip, thus allowing your PC to essentially act like a dual-processor machine. Intel's offerings include the hyperthreading technology in each core to provide a second "virtual processor" for each.

On the AMD side, you have a dual-core version of the Athlon 64 processor. As of this writing, no hardware vendor had announced adoption of the product, but AMD has announced that OS support for the dual-core instruction set will be provided for Microsoft® Windows®, Red Hat Linux 4, Solaris 10, and Novell's SUSE Linux Server 9 systems. From Intel, the first available chip is the 3.2-GHz Pentium 4 Extreme Edition 840, which will use motherboards with the new 845 chipset. Dell has already announced plans to use the device in its Dimension XPS Gen5 gaming PCs. *PC World* magazine recently tested some engineering samples of the Intel processor in a Windows-based system and reported mixed results. As one might expect, multi-threaded applications (e.g., video editing and multimedia apps) benefit significantly, but single-threading software (which includes most of your standard desktop applications) will benefit little or not at all.

Philadelphia Goes Wireless

If you (a) live in Philadelphia, (b) can afford a wireless-enabled laptop computer, (c) can't afford to pay \$40.00

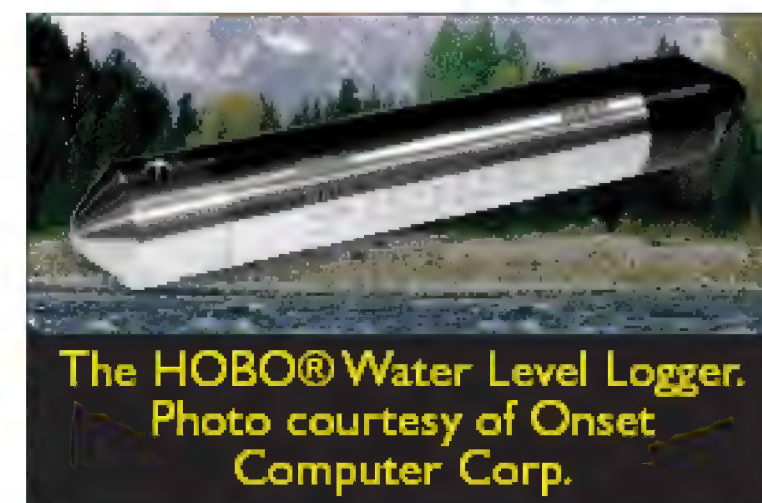
per month for wireless Internet access, but (d) can afford to pay \$20.00 per month, you're in luck. Mayor John Street and a 17-person committee have formed Wireless Philadelphia (WP), a nonprofit corporation that aims to create a city-wide wireless network. WP will draw start-up funding from foundation grants, bank loans, and other nonmunicipal sources, then hire private companies to design, deploy, and manage the network. Private service providers will also be responsible for marketing the service, billing subscribers, and providing customer service and technical support, leaving WP with the responsibility of ... well, never mind. In theory, the bureaucratic layer between users and providers will allow the city to extract wholesale-level prices from vendors, pass the savings on to users, and even keep a slice that will allow the nonprofit to generate a positive cash flow within four years. For details, see www.phila.gov/wireless. Hey, it could be the best idea since Amtrak.

Streaming Radio for Mobile Phones

The latest participant in the quest to expand the capabilities of cell phones is MSpot, Inc. (www.mspot.com), which recently announced MSpot Radio, its first product. Available on the Sprint Nationwide PCS Network for \$5.95 per month, it delivers 13 audio channels that provide eight selections of commercial-free music plus news and live sports updates from NPR®, Sporting News, MarketWatch, the Associated Press, and AccuWeather. But the concept doesn't stop there. Future MSpot services are envisioned to include premium audio and video entertainment choices. Tapping into partnerships with mobile carriers, film studios, and popular media corporations, MSpot expects to emerge as a major provider of premium mobile entertainment services. You can't imagine watching a full-length James Bond movie on a two-inch LCD screen? Never say never.

Circuits and Devices Water-Level Datalogger

If you work in the field of aquatic environmental sciences, sewage processing, or any other endeavor in which water levels are critical (or if you just want to monitor how much water your family is wasting in the bathtub), take a look at Onset Computer's HOBO® Water Level Logger, claimed to be the industry's lowest-cost device for recording water levels and temperatures in groundwater wells, lakes, wetlands, and tidal areas. It provides 0.1% of full-scale accuracy with a 30-ft measurement range and better than 0.01-ft resolution. Unlike water level loggers that rely on cumbersome vent tubes and desiccated packs for operation, this device operates as a standalone unit, which simplifies deployment and eliminates some of the mainte-



The HOBO® Water Level Logger.
Photo courtesy of Onset
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nance issues associated with vent tube-based loggers. A second HOBO Water Level Logger can be used for barometric compensation. List price, including a three-point NIST-traceable calibration check, is \$495.00. For details, visit www.onsetcomp.com

Liquid Zoom Lens for Camera Phones

At the CeBIT electronics trade show, Varioptic (www.variopic.com) demonstrated what it claims is the world's first zoom and autofocus lens for camera phones. The company's patented "electrowetting technology" uses electricity to distend or flatten two drops of liquid, to alter the border between the liquids and focus the lens. It can provide a continuous 2.5X zoom function. The company has been working on the concept with Samsung, and they expect to have commercially available products by the last quarter of this year.

New Batteries Charge in One Minute


A new lithium-ion battery design from Toshiba is said to accept an 80 percent recharge in only one minute instead of the one hour typical of currently available products. According to the company, a breakthrough technology applied to the negative electrode uses new nano-particles to prevent organic liquid electrolytes from reducing during battery recharging. The nano-particles quickly absorb and store large amounts of lithium ions without causing any deterioration in the electrode. In addition to the quick-recharge feature, the battery is said to lose only one percent of its capacity after 1,000 charge-discharge cycles, and it can release 80 percent of its capacity at temperatures as low as -40°C. The prototype measures only 3.8 by 62 by 35 mm and has a capacity of 600 mAh.


Initial applications of the technology will be in automotive and industrial sectors, where the benefits are obvious. For example, imagine driving your elec-


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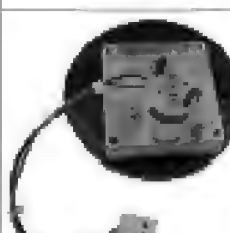
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tric vehicle into a service station and getting a recharge in a minute instead of hours. Look for commercial versions to hit the market sometime next year.

Industry and the Profession Motorola Opens Lab in India

Back in April, Motorola (www.motorola.com) announced the launch of Motorola Labs India with the official opening of an applied research lab in Bangalore. This lab — the 11th for Motorola and the company's first in

India — augments Motorola's existing India R&D infrastructure of more than 1,700 software engineers.

The mandate of the new lab is to engage in applied research in the areas of converged networks, autonomic networking, enterprise applications and embedded systems, and physical sciences. This research focus supports Motorola's vision of "seamless mobility," defined as easy, uninterrupted access to information, entertainment, communication, monitoring, and control. Motorola's R&D investment in India has grown this year to \$85 million in technology and R&D, up from approximately \$50 million in 2002. The company plans to expand this investment by 10 to 20 percent per year.

Fire Fighters' Union Opposes Antennas

The International Association of Fire Fighters (www.iaff.org)

recently announced that it is looking for funding to conduct a study of possible harmful effects of cell phone towers that are located on fire stations. According to IAFF General President Harold Schaitberger, "Fire fighters are already at a higher risk of injury and illness from the hazards of their job, but we will not tolerate our members being put in additional danger while at the station house from exposure to low-intensity radio frequency and microwave radiation from these cell towers and antennas."

It is the general belief of international governments and of the wireless telecommunications industry that no consistent increases in health risk exist from exposure to such radio frequency radiation, but the IAFF is not convinced. For a full copy of their report, you can visit www.iaff.org/safe/content/celltower/celltowerfinal.htm **NV**

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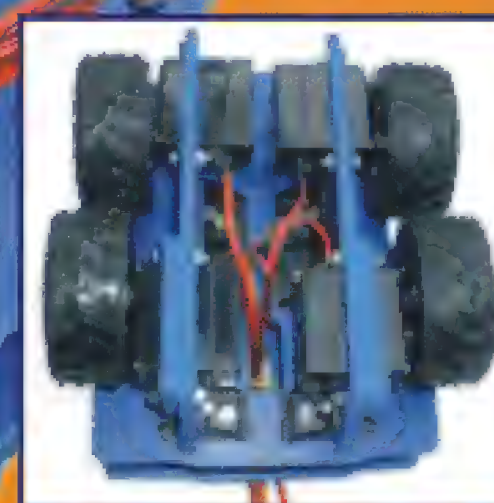
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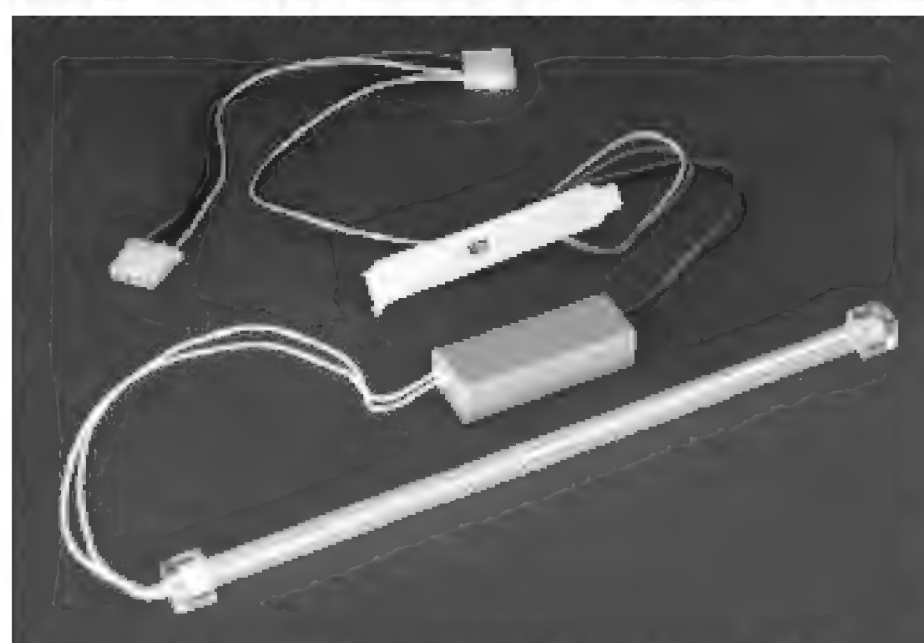


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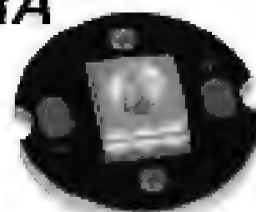
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Continued from Page 6

Reader Feedback

Dear Nuts & Volts:

I enjoyed the article "Measuring the Speed of Light" in the April 2005 issue of *Nuts & Volts*.

I have three comments that your readers might find interesting and helpful.

1. Laser light can be dangerous. Even though a laser pointer looks like a pocket flashlight, the light coming from it is quite different. Experimenters need to be sure that the laser light never shines into their eyes.

2. Some pocket laser pointers have a pocket clip that doubles as an on/off switch. It is easy to control these pointers with external circuitry by connecting one wire to the metal body of the laser pointer and another to the pocket clip.

3. Although the article is entitled "Measuring the Speed of Light," the speed of light in a vacuum cannot be measured. After realizing that the speed of light in a vacuum is a constant, physicists have *defined* the speed of light in a vacuum as *exactly* 299,792,458 meters/sec. This means that if experimenters very precisely and accurately measure the time it takes light to go a certain distance, they are really checking the measurement of that distance. In fact, the meter is *defined* as the length of a path traveled by light in a vacuum during a time interval of 1/299,792,458 seconds. [See "Physics for Scientists and Engineers," 3rd ed., by Wolfson and Pasachoff, page 5.]

George Caplan
Wellesley College in MA

Dear Nuts & Volts:

On the May 2005 "In the Blink of an Eye" article ... This is a nice, well thoughtout article with good, easy to understand content and ample safety warnings. I do have a couple of comments:

1. Bridge-Doubler. Note that when running on 120 VAC, the two lower diodes never conduct and are therefore superfluous. The benefit of this circuit is that by simply remov-

ing the wire between the common point of the C1 and C2 and the bridge, the circuit becomes a simple full wave bridge rectifier. Then, it can be used without any other changes where the input power is 240 VAC. My suspicion is that the designer copied it from a switchmode power supply (where the capability to easily change the input voltage is desirable) without also adding the comments on the benefits of this arrangement.

2. It is a simple matter to use a triac or SCR to trigger the strobe. One important thing is to make sure the trigger device is turned on fully by the trigger switch — it should be pulsed using a diac or a second small thyristor, such as in an opto-triac or opto-scr. Running the trigger circuit on one half of the flashlamp voltage (about 170 VDC) via a voltage divider makes it easier to find suitable devices. Solid-state triggering would be much more precise than the use of a relay.

3. Most of the parts for this device could be obtained from the flash unit out of a disposable camera — for no cost, if you know where to ask and convince them you won't kill yourself. In fact, then, it could run on a 1.5 V battery with no need for the AC line at all.

General information on electronic flash and strobe devices can be found on my website, www.repairfaq.org (currently redirected to repairfaq.ece.drexel.edu). It includes circuits like this one, as well as many others for anything from stroboscopes to high energy laser flashlamps.

Sam Goldwasser

Dear Nuts & Volts:

The article "The Solar Alternative" by Lorenz in your April issue contains a serious misstatement. It states "The output power is just the load resistance multiplied by the square of the voltage across it." It should be "... esistance divided into the square ...". Ohm's Law still applies in solar power applications.

E. A. Grens

Advanced Techniques for Design Engineers

The Design Cycle

Creating a Monster — Micro64 Style

Back when dinosaurs roamed the Earth (when I programmed my first microcontroller), an embedded programmer working with microcontrollers had very little in the way of program Flash and on-chip SRAM. In fact, the first microcontroller I learned to program only contained 512 bytes of EPROM (that's right ... EPROM not Flash) and 24 bytes (count them again, 24 whole bytes) of SRAM.

Obviously, I had to write my tiny programs in assembler as there real-

ly weren't any microcontroller-oriented C or Basic compilers at that time. In those days, one even had to buy the assembler!

Today's microcontroller companies provide free assembler packages complete with fancy IDEs (Integrated Development Environments) for microcontrollers with massive program Flash memories and equally expansive SRAM cores.

However, even with 128K of program Flash and upwards to 8K of SRAM on-chip, some applications

such as long-term data loggers and microcontroller-based web servers still may require more data memory than the modern, full-bodied microcontrollers can natively provide.

With that thought, what if I could show you how to build a powerful AVR-based system with 64K of program Flash, 34K of SRAM and 128 MB (yes, 128 megabytes) of removable storage without having to design a custom printed circuit board or mount any discrete components? And, as a bonus, once your 128 MB AVR system is physically assembled, you will be able to program it using AVR assembler, C, or Basic and debug your code using off-the-shelf debugging tools. Interested? Then, let's get started.

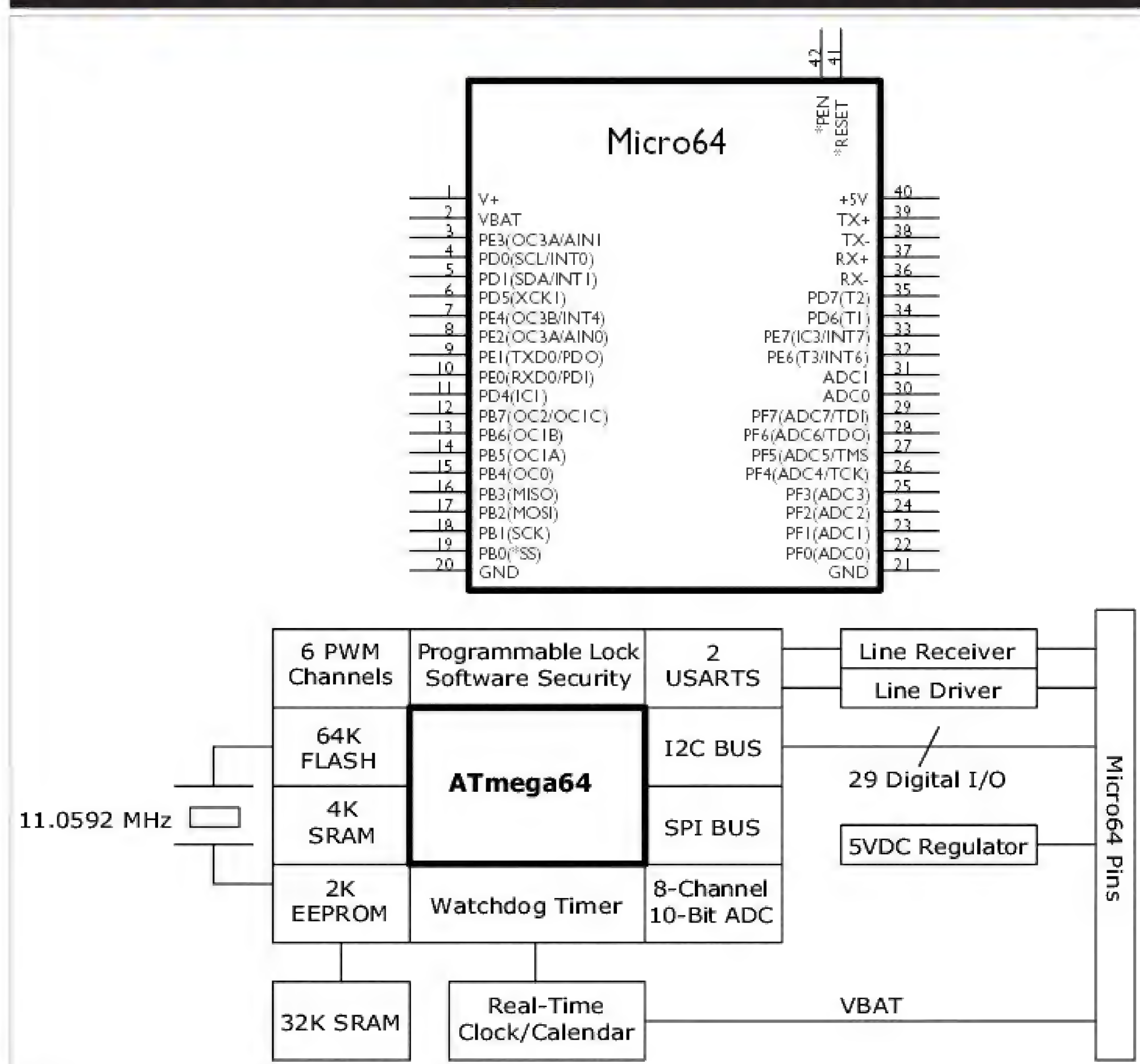
With that thought, what if I could show you how to build a powerful AVR-based system with 64K of program Flash, 34K of SRAM and 128 MB (yes, 128 megabytes) of removable storage without having to design a custom printed circuit board or mount any discrete components? And, as a bonus, once your 128 MB AVR system is physically assembled, you will be able to program it using AVR assembler, C, or Basic and debug your code using off-the-shelf debugging tools. Interested? Then, let's get started.

Creating a Monster

The whole of the 128 MB AVR-based microcontroller system is based on a black and white potted 42-pin computing block from Micromint called the Micro64. The Micro64 is an amazing little device. It measures in at 1.5 x 2.1 x 0.52 inches and, using its built-in voltage regulator, the Micro64 can be powered directly from a +6.5 VDC to +20 VDC power source or by a single regulated +5 VDC supply. Either way, the Micro64's current consumption is a paltry 55 mA (typical).

With the Micro64, you get all of the on-chip features of the Atmel ATmega64 microcontroller with the addition of a battery-backed real-time clock/calendar, a true RS-485/RS-232/RS-422 port and 32K of SRAM.

Figure 1. The Micro64 is a complete ATmega64 microcontroller system squeezed into a weather-tight 1.5 cubic inch brick. Although all of the goodies are seemingly "hidden," you can still use traditional programming and debugging tools to access the Micro64's features.



The Micro64A variant includes an additional 12-bit analog-to-digital converter.

Although the Micro64 can be programmed and debugged in the normal AVR fashion, a factory-loaded bootloader application comes as standard equipment with the Micro64 to eliminate the need for a specialized AVR programmer. Included within the Micro64 bootloader code are utilities that allow easy access to the Micro64's real-time clock, analog-to-digital converter, and I²C capabilities. A logical subsystem and physical pinout look at the Micro64 are depicted in Figure 1.

To gain a better understanding of what we will be discussing, you'll want to get your own copy of the Micro64 datasheet from the Micromint website at www.micromint.com. Although the Micromint Micro64 datasheet fully describes the Micro64 proper, it doesn't really fully cover the intricacies of the ATmega64. So, you may also want to download the ATmega64 datasheet from www.atmel.com.

I found the ATmega64 datasheet to be very useful while I was writing the Micro64 code for this project. You'll find that there are many native ATmega64 features that complement the Micro64's factory hardware.

The brains of our little "monster" lie within the potting of the Micro64 module. The "brawn" of the project is contained on the small printed circuit board you see in Figure 2. The device in the Figure 2 close-up shot is called ALFAT/SD. Everything needed to control and manage the 128 MB SD/MMC (Secure Digital/MultiMedia Card) module in the ALFAT/SD socket is contained within the on-board 32-bit Philips LPC2114 ARM processor.

As its name implies, ALFAT/SD is a microcontroller-based implementation of the FAT file system that uses the SD/MMC media format for data storage. The presence of a FAT file system means that you can swap files between your ALFAT/SD-equipped Micro64 and your personal computer. This is a good thing if you want to collect data using the Micro64 for crunching in a PC spreadsheet or pre-load files from a PC to be used by the

Micro64, which is in charge of the ALFAT/SD.

With the proliferation of digital cameras that use the SD/MMC media, SD/MMC personal computer interfaces are common. I have an E Machines PC (working as an FTP server) that comes with a built-in SD/MMC reader/writer interface. You can also purchase inexpensive USB-based SD/MMC/CompactFlash interfaces for your desktop PC for as little as \$30.00 from many of the Internet retailers that advertise in this magazine.

As you can see in the ALFAT/SD close-up, ALFAT/SD only pins out a total of 10 five-volt-tolerant communications and control I/O lines. The minimal ALFAT/SD I/O interface and the LPC2114's ability to run at +3.3 VDC and manipulate standard TTL logic levels on its I/O pins makes it

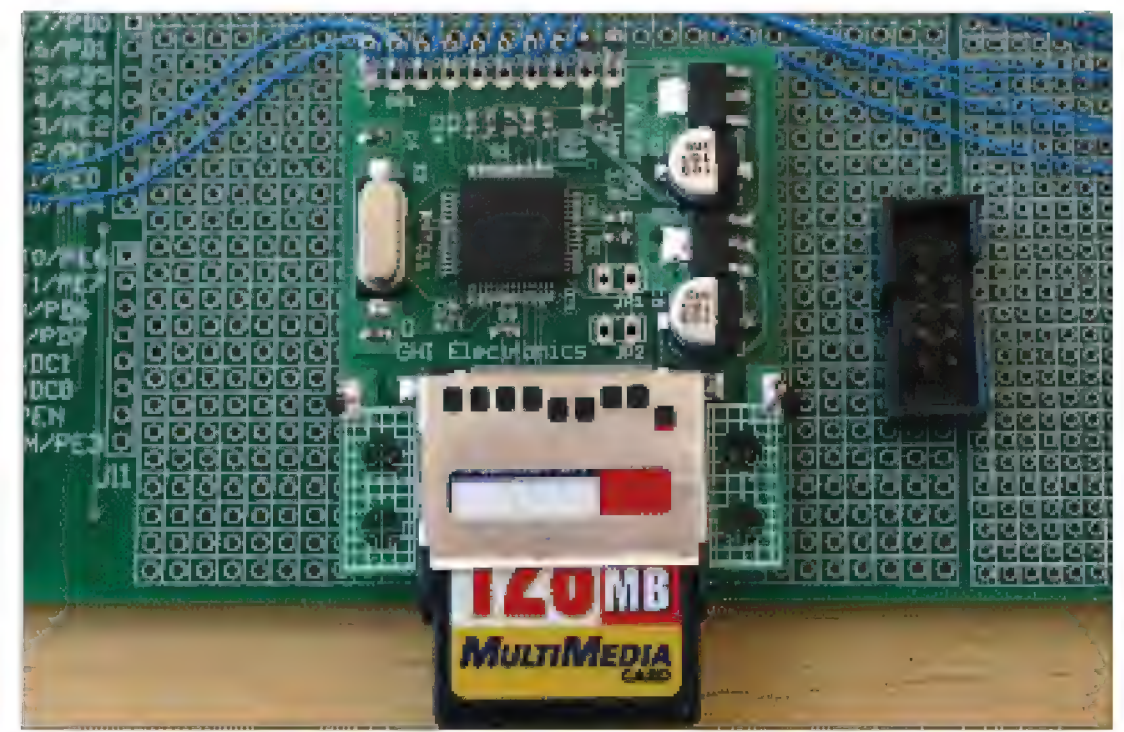


Figure 2. This is the ALFAT/SD from GHI Electronics. Everything necessary to manage the 128 MB SD card is contained within the ALFAT/SD's on-board microcontroller.

very easy to communicate with the ALFAT/SD. Commands and data can be moved between the Micro64 and the ALFAT/SD using standard ASCII text or a more advanced proprietary scheme called frame mode.

In either communications mode, the ALFAT/SD can connect to the Micro64 using a standard TTL

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Figure 3. The only wires you don't see in this shot are the JTAGICE mkII JTAG connections and the two power pin connections on the ALFAT/SD 10-pin I/O connector. My only custom additions to the Micro64 Development Board were the LED, the 10-pin AVR programming socket, and the 10-pin JTAGICE mkII JTAG interface socket.

USART-to-USART connection or via the Micro64's SPI port. A clean +5 VDC to +12 VDC power source that can supply 50 mA is all you need to power up and run the ALFAT/SD.

Like the Micro64, the ALFAT/SD

comes equipped with a factory-installed bootloader that allows the ALFAT/SD's firmware to be effortlessly upgraded in the field. I can't list every nuance of the ALFAT/SD feature set here. However, you can get a full ALFAT/SD Operations Manual, the latest ALFAT/SD firmware, and an ALFAT/SD schematic from the GHI Electronics website at www.ghielectronics.com

My fully assembled multi-megabyte "monster" and the JTAGICE mkII are shown in Figure 3. I opted to use the Micromint Micro64

Development Board as a base platform for my Micro64-ALFAT/SD setup. Both the ALFAT/SD and the Micro64 are pinned for .1-inch hole spacing. So, you don't have to go with the prefab motherboard scheme I used as you

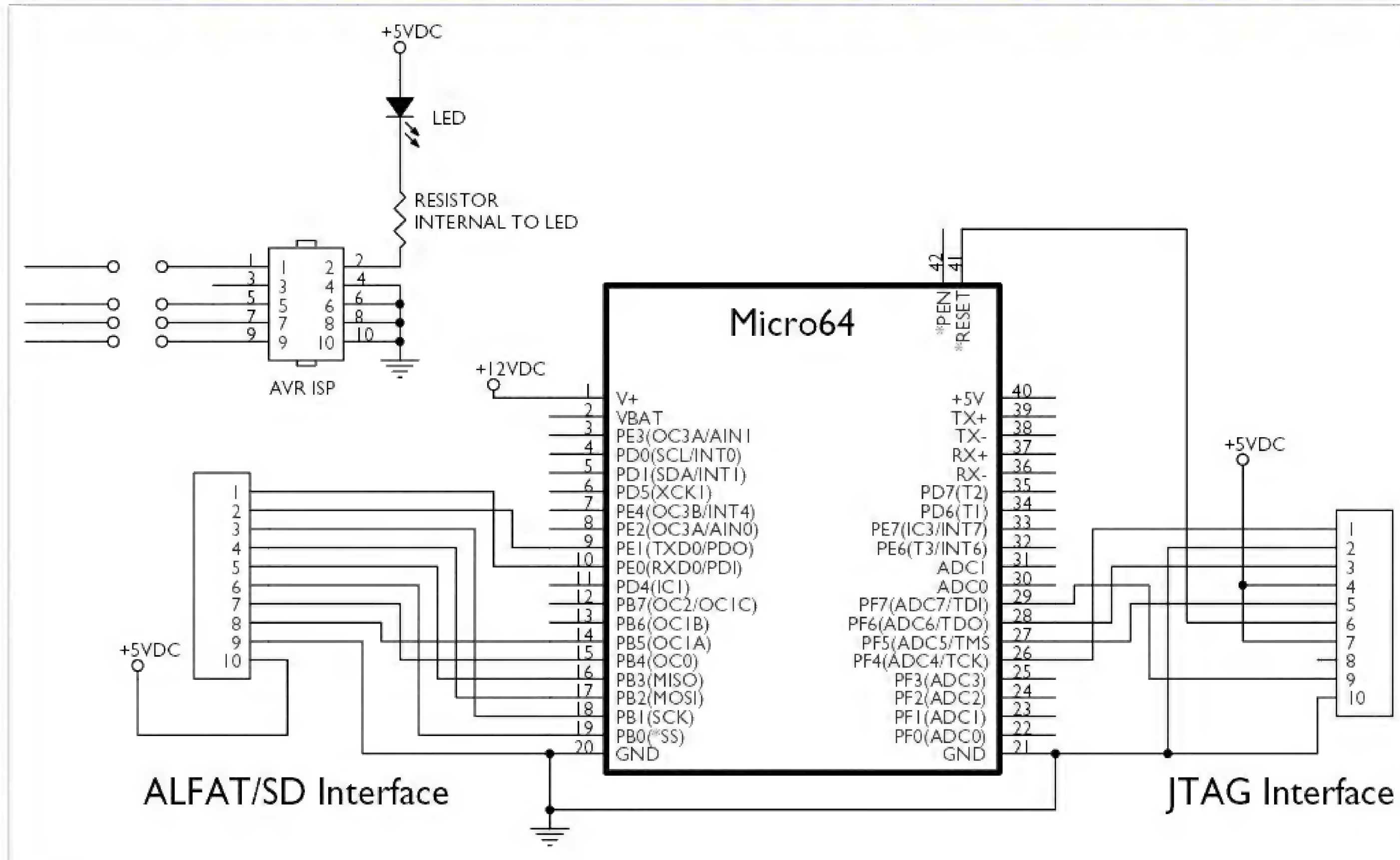
can easily use standard .1-inch breadboard with point-to-point and wire wrap techniques to interconnect and power the ALFAT/SD and the Micro64.

I went with the Micro64 Development Board because it incorporated all of the necessary debugging hardware, serial ports, and power supply components I needed to support the ALFAT/SD and the Micro64. Using the Micro64 Development Board also makes it much easier for me to show you the details of the ALFAT/SD and Micro64 physical interconnects.

As you can see in Figure 3, I used wire wrap techniques to connect the ALFAT/SD to the Micro64 header pins on the Micro64 Development Board. The few electrical connections that I made between the ALFAT/SD and the Micro64 are graphically depicted in Figure 4.

If you already have your Micro64 datasheet, you'll notice that all of the Micro64 Development Board's serial

Figure 4. The high level of integration found in the ALFAT/SD and the Micro64 make for an easy assembly process. It takes less than 50 "connects" to put it all together. Note that I installed an LED with a built-in current limiting resistor. The Micro64 Development Board has pads reserved for the current limiting resistor and I simply shorted them.



port interfaces can be configured using jumpers. The Micro64 is based on the ATmega64, which contains two USARTs — USART0 and USART1.

The Micro64 on-board RS-232 converter IC can be jumpered in or out of either of the Micro64's USART circuits. This allowed me to disconnect the ALFAT/SD-to-Micro64 USART connection and tie the ALFAT/SD UART directly to either of the Micro64 Development Board's serial port interfaces. Being able to jumper in this ad-hoc ALFAT/SD serial port arrangement allows easy access to the ALFAT/SD's USART using an ASCII terminal emulator running on a PC.

The Micro64's bootloader utilizes one of the Micro64 Development Board's serial interfaces and one of the Micro64's USARTs (USART1). If you're using the Micro64 bootloader to reprogram the Micro64 after every debug cycle, you will tie up one of the Micro64 Development Board's serial interfaces

and possibly one of the Micro64's USARTs during program development.

Although you'll lose the ability to employ the Micro64 bootloader, using the JTAG interface for programming and debugging frees up both of the Micro64 Development Board's serial interfaces and the Micro64's USARTs. Take another look at Figure 2 as it is a good look at the 10-pin JTAG connector I added to the right of the ALFAT/SD.

In Figure 3, my JTAGICE mkII is shown coupled to the Micro64 via the Micro64 Development Board's newly added JTAG connector. Note that I also added a 10-pin AVR ISP programming connector to the Micro64 Development Board, which is directly left of the pair of nine-pin shell connectors.

Adding this programming interface was absolutely necessary as I had to use an AVR ISP programming dongle to activate the JTAG interface fuses in the Micro64's internal

ATmega64 microcontroller.

Believe it or not, you now have enough information to assemble your own set of Micro64-ALFAT/SD hardware. My experience with the Micro64 and ALFAT/SD hardware was painless. You won't need any Novocaine before you write the code for this project, either.

The ALFAT/SD I/O Interface

From a programming perspective, the ALFAT/SD 10-pin I/O interface is logically perfect. In ALFAT/SD UART mode, pins 1 and 2 of the ALFAT/SD I/O interface form a null modem arrangement with the Micro64's USART0, which is pinned out of Micro64 I/O pins PE0(RX) and PE1(TX). The PE0 and PE1 I/O pins leave their RX and TX USART duties behind and become inputs when the ALFAT/SD and Micro64 are switched

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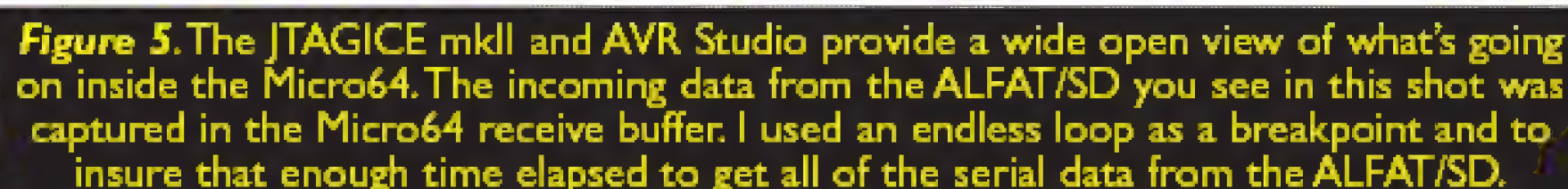
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The ALFAT/SD will drive the RTS pin low when its 256-byte FIFO (First In First Out) fills up and expects the host to drive the CTS pin high in return so it can attempt to empty the FIFO and catch up. I've never seen this happen. The RTS and CTS pins are wired to suitable

For SPI to work as designed, the ALFAT/SD's MISO line must act as the ALFAT/SD's SPI data transmit line (Slave Out). The SPI I/O pin logic is simply reversed for the MOSI

A simple flip of the logic level on the UART/SPI* pin (PB5) toggles the

communications mode of the ALFAT/SD module between UART mode and SPI mode. Nothing between the Micro64 and the ALFAT/SD I/O interface has to be rewired to run in either UART or SPI mode. Only the way the pins are used by the firmware changes. That's logically perfect to me. With that, let's put that perfectly logical ALFAT/SD I/O interface to work.

Coding the ALFAT/SD UART-Mode Driver

When coding the Micro64, you can use any version of AVR assembler, AVR C compiler, or AVR Basic compiler that suits you. I have chosen to use ICCAVR from ImageCraft, as the ICCAVR C source code is easily ported to other languages and the ICCAVR debug files work exceptionally well with AVR Studio and the JTAGICE mkII.

When powered up, the ALFAT/SD spits out the character string "BL" followed by a pair of carriage return (0x0D) and line feed (0x0A) characters. This is true for both UART and SPI modes. In fact, the operational character streams for UART and SPI modes are identical. The only difference between the two ALFAT/SD communications methods is how you get the data.

During ALFAT/SD operation, you can obtain the identical stream of data bytes for a given operation from the ALFAT/SD UART in UART mode or from the ALFAT/SD SPI interface when SPI mode is invoked. Figure 5 is a screen shot of the JTAGICE mkII debug session output captured following the initialization of the Micro64 USART and the ALFAT/SD in UART mode.

For now, ignore the code in the debug source window of Figure 5 beginning with `init_spi()`. The data captured in the `USART_RTxBuf` array was sent by the ALFAT/SD in UART mode following a reset that was issued as a result of the Micro64 toggling the ALFAT RESET* line from TTL low to TTL high. The data following the "BL" sequence (the banner message) was sent after the Micro64 acknowledged the reception of the

"BL" character sequence by transmitting the character "R."

Let's examine Listing 1 to determine what has transpired to this point. After disabling all interrupts (`CLI()`), the Micro64 drives the ALFAT/SD CTS line low to enable the ALFAT/SD to transmit data to the Micro64. The next step (`init_usart0()`) sets the data direction registers for the Micro64 I/O

ports `PORTB` and `PORTE` and sets the `PORTB` bits to force the ALFAT/SD into UART mode while driving the CTS line low to enable ALFAT/SD transmission.

The Micro64's `USART0` is then configured for 115,200 bps, which is the default baud rate for the level of ALFAT/SD firmware we are currently running. The final steps of the

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Listing 1. There's really no fancy coding in the listing. We're simply talking to the ALFAT/SD serially just as we would with any other serial device.

```
void main(void)
{
    unsigned int cc;
    char rc;

    CLI();                //disable global interrupts
    init_usart0();         //initialize USART0
    SEI();                //enable global interrupts
    rc = reset_ALFAT_232(); //reset ALFAT/SD into UART mode
                          //look for "BL"
                          //parse for ">" prompt
    while(1){++cc;}       //loop here forever

    init_spi();
    reset_ALFAT_spi();
    while(1);
}
*****
//USART0 initialisation
// desired baud rate:115200
// char size: 8 bit
// parity: Disabled
void init_usart0(void)
{
    DDRB = 0x37; //00110111
    DDRE = 0x02; //00000010
    PORTB = 0x7B; //11101011 CTS=0,UART MODE

    UCSROB = 0x00; //disable while setting baud rate
    UCSROA = 0x00;
    UCSROC = 0x06;
    UBRROL = 0x05; //set baud rate lo 115200
    UBRROH = 0x00; //set baud rate hi
    UCSROB = 0x98; //enable USART0 TX and RX, enable receive interrupt
    // flush receive buffer
    USART_RxTail = 0x00;
    USART_RxHead = 0x00;
    USART_TxTail = 0x00;
    USART_TxHead = 0x00;
}
*****
char reset_ALFAT_232()
{
    unsigned int cc;
    unsigned char drive,temp;

    drive = 'Z';          //current drive letter
    clr_RST;              //reset ALFAT/SD
    delay_ms(10);
    set_RST;
    cc = 0;
    delay_ms(50);         //give it some startup time
    /* LOOK FOR "BL" STRING
    do{
        rdata[cc++] = recvchar();
    }while(CharInQueue());
    if(rdata[0] == 'B' && rdata[1] == 'L')
    /* IF "BL" FOUND, SEND R
        sendchar('R');
        delay_ms(50);
    /* GET THE ALFAT/SD BANNER
    do{
        temp = recvchar();
    }while(CharInQueue());
    /* TURN OFF ECHO
```

USART0 initialization routine enable the USART0 transmitter and receiver, enable the receive interrupt, and clear the transmit and receive buffer pointers.

Now is a good time to provide a high-level overview of the USART0 interrupt algorithm. I'm not going to display the USART0 interrupt handler code here or go into detail as to how it works. However, I will post a complete copy of the Micro64-ALFAT/SD source code on the *Nuts & Volts* website for you.

For those of you that may want the byte-by-byte detail, the USART0 interrupt handler code was "lifted" from Fred Eady's book, *Networking and Internetworking with Microcontrollers*, which explains the workings of the USART0 interrupt handler code in minute detail.

The Micro64 USART code is comprised of five individual routines. These routines include a receive interrupt handler, a transmit interrupt handler, a send character routine, a receive character routine, and a receive buffer character-available routine. The size of the transmit buffer and receive buffer can be altered in the code and the buffer sizes must fall on even byte boundaries (1, 2, 4, 8, 16, 32, etc.). The buffer sizes I have used for this project are 256 bytes for the receive buffer and 16 bytes for the transmit buffer.

The overall operation of the USART0 interrupt mechanism revolves around the time-proven heads and tails circular buffer algorithm. When the head pointer and the tail pointer are equal in a circular buffer, it is considered to be empty. To avoid a buffer overrun condition, a buffer mask value — which is one byte less than the buffer size — is compared to the buffer's head and tail values with every operation that uses the buffer. An overrun condition means that you have overstuffing the buffer and overwritten some data that had not yet been processed.

The receive interrupt handler gets characters from the Micro64's USART0, stuffs them into the receive buffer, and increments the receive

buffer head pointer. The application uses the receive character routine to retrieve the incoming serial data for processing.

The receive character routine removes characters from the receive buffer that are pointed to by the receive buffer's tail pointer and then increments the buffer tail pointer. The receive buffer character-available routine simply compares the receive buffer's head and tail pointers. If they're equal, the receive buffer is empty. Otherwise, there is data in the receive buffer that can be retrieved and used by the application.

The transmit interrupt handler works in the same circular buffer fashion as the receive interrupt handler except there is no associated transmit buffer full check routine. Instead, the send character routine stuffs the transmit buffer, increments the transmit buffer's head pointer, and checks for available free space within the transmit buffer.

The transmit interrupt handler pushes data out of the transmit buffer to USART0 for transmission using the transmit buffer tail pointer. If the transmit buffer is full (transmit buffer head pointer equal to transmit buffer tail pointer), the send character routine waits until a character finishes processing in the transmit interrupt handler and frees a byte of space in the transmit buffer before stuffing another character into the transmit buffer.

For both the USART0 transmit and receive operations, the buffer pointers are incremented, checked for validity, and adjusted programmatically by the set of interrupt handler routines. That makes it easy to capture the serial data stream and produce debug graphics of the buffered data like what I've shown you in Figure 5.

Okay. Let's get back to the thread we were following in Listing 1. Thus far, we've set up the Micro64's USART0 and prepared the ALFAT/SD for UART-mode operation. Now, we can reset the ALFAT/SD and verify that the ALFAT/SD is ready to accept commands and exchange data. The final third of Listing 1 is the

Listing 1 continued ...

```
printf("EE 0\r");
delay_ms(50);
/* GET Z:> PROMPT
do{
    temp = recvchar();
}while(CharInQueue());
/* CHANGE DRIVE TO SD/MMC MODULE
printf("A:\r");
cc = 0;
delay_ms(50);
/* CHECK FOR A:> PROMPT
do{
    rdata[cc++] = recvchar();
}while(CharInQueue());
if(rdata[cc-3] == 'A' && rdata[cc-2] == ':' && rdata[cc-1] == '>')
    drive = 'A';
    return(drive);
}
```

ALFAT/SD UART mode reset code. If the ALFAT/SD is loaded with a working version of firmware, we should receive the "BL" character sequence and reply with an "R," which results in the ALFAT/SD sending a banner message to the Micro64.

I've superimposed the ending

receive buffer segment that contains the end of the ALFAT/SD banner onto the right side of Figure 5. Note that the banner ends with a "Z:>" prompt. The ALFAT/SD isn't a DOS device, but to make things easy it uses DOS-like syntax. The "Z:>" prompt tells us that the ALFAT/SD is ready

Listing 2. Once the SPI read and write routines are hammered out, the rest is just as easy as communicating in UART mode.

```
void main(void)
{
    unsigned int cc;
    char rc;
    /*
    CLI();
    clr_CTS;
    init_usart0();
    SEI();
    rc = reset_ALFAT_232();
    while(1){++cc;}
    */
    init_spi(); //SPI code starts here
    reset_ALFAT_spi();
    while(1);
}
*****
void init_spi(void)
{
    unsigned char temp;

    DDRB = 0x37; //00110111
    DDRE = 0x00;
    PORTE = 0x00; //turn off internal pullups
    SPCR = 0x55; //01010101
    PORTB = 0x18; //00011000
    temp = SPSR; //clear SPIF bit in SPSR
    temp = SPDR;
}
*****
char reset_ALFAT_spi()
{
    unsigned int cc;
    unsigned char drive,temp;

    drive = 'Z'; //current drive letter
```


Listing 2 continued ...

```

clr_RST;                                //reset ALFAT/SD
delay_ms(10);
set_RST;
cc = 0;
delay_ms(50);                            //give it some startup time
/* LOOK FOR "BL" STRING
do{
    rdata[cc++] = read_spi();
}while(PINE & DATARDY);
/* IF "BL" FOUND, SEND R
if(rdata[0] == 'B' && rdata[1] == 'L')
    write_spi('R');
    temp = read_spi();    //read echoed R
/* GET ALFAT/SD BANNER MESSAGE
do{
    rdata[cc++] = read_spi();
}while(PINE & DATARDY);
/* TURN OFF SPI ECHO
write_spi('E');
temp = read_spi();
write_spi('E');
temp = read_spi();
write_spi(0x20);
temp = read_spi();
write_spi('0');
temp = read_spi();
write_spi(0x0D);
temp = read_spi();
cc = 0;
/* GET Z:> PROMPT
do{
    rdata[cc++] = read_spi();
}while(PINE & DATARDY);
/* CHANGE DRIVE TO SD/MMC MODULE
write_spi('A');
write_spi(':');
write_spi('\r');
cc = 0;
delay_ms(50);
/* CHECK FOR A:> PROMPT
do{
    rdata[cc++] = read_spi();
}while(PINE & DATARDY);
if(rdata[cc-3] == 'A' && rdata[cc-2] == ':' && rdata[cc-1] == '>')
    drive = 'A';
    return(drive);
}

```

for commands and is not “attached” to the SD/MMC media, which is known as “A:” to the ALFAT/SD.

To get the A: drive online, all we do is what we would do at a DOS prompt. We send an “A:” followed by a carriage return in the form of `printf("A:\r")`. The ALFAT/SD should return what looks like a DOS prompt for the A drive (A:>). Since the Micro64 USART0’s interrupt handlers automatically index the data into a buffer and point to the next available buffer entry, I simply collected what should be the A:> prompt data into an array called `rdata` and backed up

three bytes from the end of the supposed prompt data to check for the “A:>” prompt message.

If the “A:>” prompt was received, the character “A” is returned to the calling function. Otherwise, a “Z” is returned, which says that the SD/MMC module was not successfully attached to the ALFAT/SD. Note that I turned off the ALFAT/SD’s serial data echo function. This must be done to operate in UART mode at high speed.

It’s that easy. We are now ready to create files and folders on the SD/MMC module, but before we go there, let’s do everything we just did in SPI mode.

Coding the ALFAT/SD SPI-Mode Driver

Listing 2 is the SPI version of the UART mode code we just completed. Notice that the Micro64 PORTB and PORTE bit patterns have been altered to accommodate the ALFAT/SD I/O interface operating in SPI mode. Once one gets the SPI (Serial Peripheral Interface) read and write routines in order, communicating using the SPI protocol is a simple thing.

SPI uses a Master/Slave concept. In its most basic form, SPI networks have only one Master. However, it is possible to have multiple Masters. The Master uses the active-low SS^* (SS^* is SPI SSEL on the ALFAT/SD I/O interface) line to select a Slave to communicate with. Once the Slave is selected, the Master clocks data to and from the Slave using the SCK line.

The ALFAT/SD and the Micro64 are both eight-bit SPI devices, which means that eight bits of data are clocked in each direction for every SPI cycle. When the Master is finished with the Slave, the SS^* line is raised, which deactivates the Slave’s capability to use the SPI bus.

With regard to the ALFAT/SD, the idle level of the SPI clock (SCK) must be logically low. The SCK idle parameter is set by clearing bit 3 (Clock Polarity) of the Micro64’s SPI Control Register (SPCR). On the rising edge of SCK, the ALFAT/SD — which is a Slave device — reads the incoming data on its MOSI line. On the falling edge of SCK, the ALFAT/SD drives data out to the Master on its MISO line.

To allow the Master to read data from the ALFAT/SD on the falling edge requires us to set bit 2 (Clock Phase) of the SPCR. The end of an SPI data transfer cycle is signaled by the setting of the SPIF bit (SPI Interrupt Flag) in the SPSR (SPI Status Register).

The SPI code in Listing 2 is very similar to the UART-mode code in Listing 1. Disabling the echo function in the SPI-mode code eliminates having to perform a read after every write. It’s a bit more important to dis-

able echo in SPI mode as we don't have the luxury of ignoring data that is automatically collected by interrupt-driven buffers. A SPI interrupt scheme is possible, but I won't explore it here.

The UART-mode sendchar and recvchar functions are replaced by the write_spi and read_spi functions, respectively. However, the resultant character stream looks exactly like the UART-mode capture you see in Figure 5.

A:>

The Micro64 is seeing the "A:>" prompt. That means you're ready to read and write the SD/MMC media using the Micro64 and the SPI mode and UART mode drivers we've written. The ALFAT/SD Operation Manual suggests that you use the UART mode over the SPI mode if you have an available serial port on your microcontroller. A look at Listing 3 supports that statement. SPI mode needs a bit more babysitting than UART mode, but both are viable ways to get data to and from the SD/MMC media.

By describing the construction of the ALFAT/SD driver code, I've simply shown you coding things that you won't find in the Micro64 or ALFAT/SD datasheets. All that's left to do is for you to use the ALFAT/SD driver code we've just created in conjunction with the ALFAT/SD, ATmega64, and Micro64 datasheets to create your own monster. **NV**

Resources

ALFAT/SD

GHI Electronics; Saelig Company
www.ghielectronics.com
www.saelig.com

ICCAVR C Compiler

ImageCraft
www.imagecraft.com

Micro64

Micromint
www.micromint.com

JTAGICE mkII

Atmel
www.atmel.com

Listing 3. The UART-mode code is far less busy than the SPI-mode code. However, if your application is using your microcontroller's only serial port, the SPI mode is a faster alternative although it is more complicated to implement.

```
char open_file[] = "OF W#1 nutsvolt.txt\r";
char write_file[] = "WF #1 E\r";
char file_contents[] = "NUTS AND VOLTS";
char close_file[] = "CF #1\r";

void main(void)
{
    unsigned int cc,i;
    char rc;
    /* UART MODE CODE BEGINS HERE
    CLI();
    clr_CTS;
    init_usart0();
    SEI();
    rc = reset_ALFAT_232();

    printf("OF W#1 nutsvolt.txt\r"); //open file
    printf("WF #1 E\r"); //write to file
    while(!(CharInQueue())); //wait for quotes (")
    printf("NUTS AND VOLTS"); //send data
    while(!(CharInQueue())); //wait for quotes (")
    printf("CF #1\r"); //close file
    while(1){++cc;} //spin here forever

    /* UART MODE CODE ENDS HERE
    *****
    /* SPI MODE CODE STARTS HERE

    init_spi();
    reset_ALFAT_spi();

    cc = 0;
    for(i=0;i<strlen(open_file);++i) //open file
        write_spi(open_file[i]);
    do{
        rdata[cc++] = read_spi(); //wait for prompt
    }while(PINE & DATARDY);

    for(i=0;i<strlen(write_file);++i) //write to file
        write_spi(write_file[i]);
    do{
        //wait for starting
        quotes (")
        rdata[cc++] = read_spi();
    }while(PINE & DATARDY);

    for(i=0;i<strlen(file_contents);++i) //send data
        write_spi(file_contents[i]);
    do{
        //wait for ending quotes
        (")
        rdata[cc++] = read_spi();
    }while(PINE & DATARDY);

    for(i=0;i<strlen(close_file);++i) //close file
        write_spi(close_file[i]);

    do{
        //wait for prompt
        rdata[cc++] = read_spi();
    }while(PINE & DATARDY);

    while(1); //spin here forever

    /* SPI MODE CODE ENDS HERE
}
```


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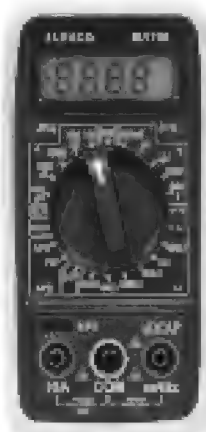
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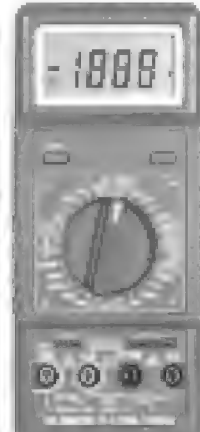
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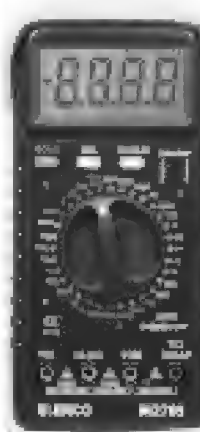
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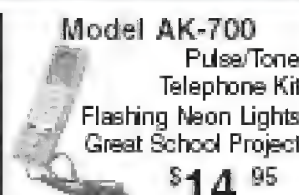
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Tech Forum

QUESTIONS

I need to locate a transformer that meets the following requirements:

1. Small physical size (toroid/E-core/other)

2. Low/reasonable cost

3. 30:1 Step-up transformer

Input 6 VDC (chopped square wave) running at around 17.5 kHz

Output approx. 180 VDC (chopped square wave)

Input — Primary approx. 15 turns of #24 magnet wire

Output — Secondary approx. 450 turns of #34 magnet wire

If I wind a toroid, what type of material do I use (powered iron core)?

I would like to have the size as close to a FT-50 or FT-82 as possible.

Can anyone help me locate/design/wind this transformer?

#06051

**Larry Kraemer
Jackson, MO**

I'm using a PIC microcontroller to send data serially to my PC as sort of a data logger. I've been using hyperterminal to capture the info, but I need a time stamp on each incoming line to tell what time the data was taken. The time stamp should be system or actual time. I've tried using a serial port monitor program by Retisoft, but it uses its own stopwatch-style stamp, which doesn't mean a whole lot to me. I

don't have the time or money to add something like Solutions Cubed's pocketwatch, so any programs that record serial data with a system-based time stamp would be a huge help!

#06052

**Ryan
via Internet**

I am searching for an electronic simulation package that can account for the self-heating property of semiconductors. Given a user specified ambient temperature and the thermal resistance as a constant, the simulation would not only adjust the bias conditions (V and I) due to the rise in junction temp, but it would also tell the final junction temp. Any recommendations?

#06053

**Dean Larsen
via Internet**

There is an Internet provider (ISP) in Calypso, NC which provides broadband Internet service with microwave radio:

www.nboxwireless.net/

I think they only cover about 10 miles around their radio tower. I'm told that they rent an antenna location on a broadcast or cell phone tower and I think they operate around 5 GHz.

We need someone to put something like that in our community, as the phone company will not install DSL lines out here because there is not enough revenue to pay for new fiber optic cables.

Our cable TV is provided by Adelphia who has been in bankruptcy for about two years. They can't keep the present cable TV service running properly, let alone afford to upgrade the cable lines for broadband Internet service.

Our only hope is to get something like this "nboxwireless" service.

I guess it works something like WiFi or WiMax, but has to have connection directly into the Internet "backbone."

Who would you have to talk to in order to get an ISP connected into the

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- 1) Circuit Design
- 2) Electronic Theory
- 3) Problem Solving
- 4) Other Similar Topics

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- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

Internet system?

If a person decided to put in their own Internet ISP server, what would it take/cost to connect into the Internet? Does Cox, Roadrunner, Starband, Risp, or other local ISP owners have to pay someone to connect into the world-wide system?

Of course, it would be necessary to lease a dedicated phone line or DSL link or something to connect the

ISP server into the web.

There are amateur radio bands at:

1270 MHz to 1300 MHz
2300 MHz to 2450 MHz
3300 MHz to 3500 MHz
5650 MHz to 5925 MHz
10.0 GHz to 10.5 GHz
24.0 GHz to 24.25 GHz

If we could find transmit/receive

equipment for one of those bands and the LAN equipment to interface, might we be able to set up something that members of our amateur radio club could use?

How about a source of radio equipment that would operate in those bands and what LAN equipment would be required for interfacing?

Any other suggestions?

#06054

**Curt
WB4WAA**

I have several refrigeration controllers for store produce coolers that I cannot find any programming documentation on and I'm hoping that someone can help.

I have a Cool/Delay Heat controller with dual temp probes. It's made by McLean Midwest. It has the part name Zero McLean on the wiring label. The part number is 10-1106-33 Rev: 0.

I would appreciate any information available — especially programming info.

#06055

**Bill Mayhar
Salem, OR**

ANSWERS

[#04054 - April 2005]

I have a pair of RF modules salvaged from a 900 MHz cordless phone and the corresponding base. One of them is marked "BRF-140-0601 RF Module" and both have headers with pins marked "T+", "ST", "AI", "GN", "SQ", "DI", "AO", "R+", and "CL." I've come up with several good guesses as to the meaning of the pins, but I'm hoping someone can give me definitive answers.

Does anyone know who makes this, or where I can find the data sheet? Would these modules work as two-way radio modems?

Getting details to the RF module may be as simple as visiting the FCC (Federal Communications Commission) website. Take a look at the serial number plate that is on the

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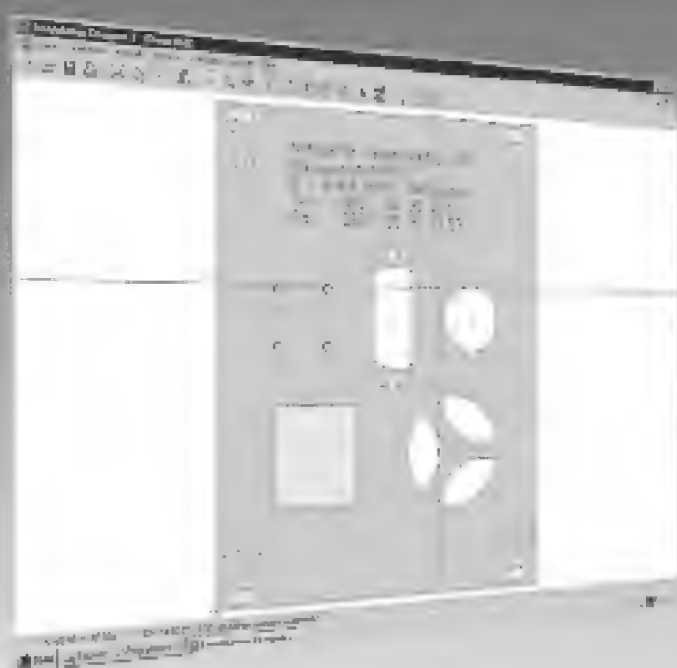
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mobile handset. On it will be an FCC Part 15 registration ID number (ignore the Part 68 ID).

Next, visit <https://gulfoss2.fcc.gov/prod/oet/cf/eas/reports/GenericSearch.cfm> and enter the full ID number into the search form. You will be presented with links to more information about the cordless phone, including detailed schematics. In some cases, the component sources are included. In any event, there will be plenty of data that you can use to help hack the RF module.

**Thomas B.
Folsom, CA**

[#04052 - April 2005]

In the winter time of northern climates, it is a great advantage to know if your car's 120 volt block heater is actually working. Presently, extension cords can be purchased that have a lighted end that show the presence of voltage. However, I am looking for a simple circuit to build into the male AC plug of the block heater, or in-line with the cord, that would detect current flow (typically about four amps AC). Preferably the indicator would be an LED or neon bulb.

#1 This circuit monitors the current flowing to the block heater and lights a pair of LEDs. Use a short extension cord and cut into the wire that connects to the narrow power pin and install the two 0.5 ohm resistors in line. This drops approximately one volt when the heater is drawing four amps of line current. The transformer is wired backwards to step up the voltage to approximately 10 volts, which lights the green LEDs. The LEDs are wired in reverse polarity to each other to light on alternate half cycles.

The part numbers indicate parts from www.hosfelt.com — an inexpensive source for the parts.

**Denis Kuwahara
Port Orchard, WA**

#2 What you need to sense the current is called a current transformer. However, they are a bit hard to find. A suitable five-amp current transformer is Amveco Part No. AC-1005, Digi-Key Part No. TE1005-ND. It has a 1,000:1 turns ratio.

No doubt, you know that a regular transformer changes voltage, for example, from 120 VAC (V_p) to 6 VAC (V_s) in proportion to the turns ratio:

$$V_p/V_s = N_p/N_s$$

where V_p = primary voltage, V_s = secondary voltage, N_p = number of primary turns, N_s = number of secondary turns.

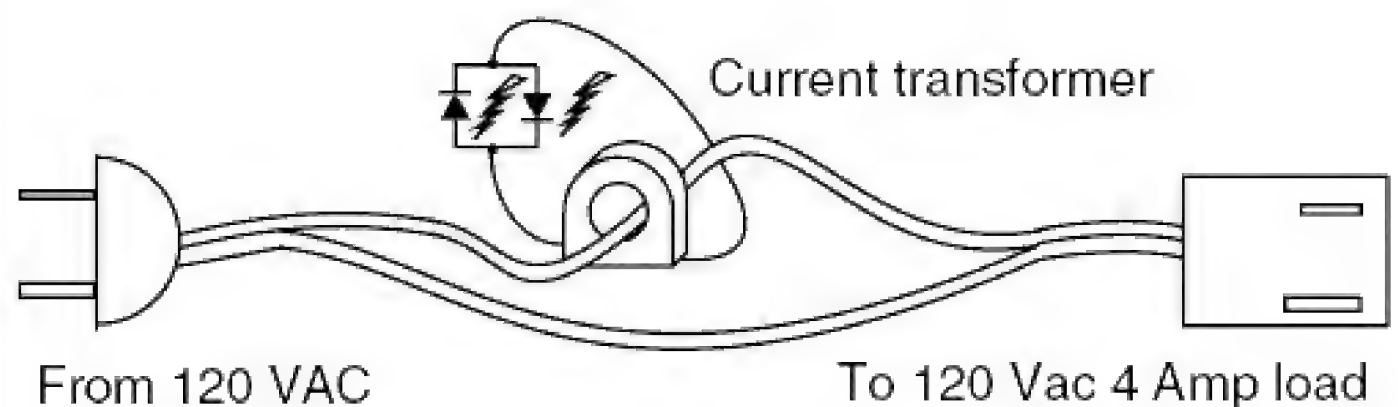
Less well known is the fact that a transformer changes, or transforms current, in inverse proportion to the turns ratio:

$$I_s/I_p = N_p/N_s$$

where I_s = secondary current, I_p = primary current.

The Amveco part will sense your four amps and convert it to 4 mA (divide four amps by 1,000). The 4 mA will drive an LED indicator (pair due to AC). Thread the hot wire — associated with the skinny plug blade — of a short extension cord through the center of the current transformer as shown in the figure below. The pair of transformer sense wires are routed to a pair of anti-parallel LEDs.

Plug the cord into 120 VAC. The LED pair should light when your four-amp heater is plugged into the cord outlet.



An alternate solution using a power resistor as a current sensor is shown in the next figure. The idea is to size a resistor to drop enough voltage to light an LED when passing a four amp current. Only use a red LED for this application because they have a lower forward voltage

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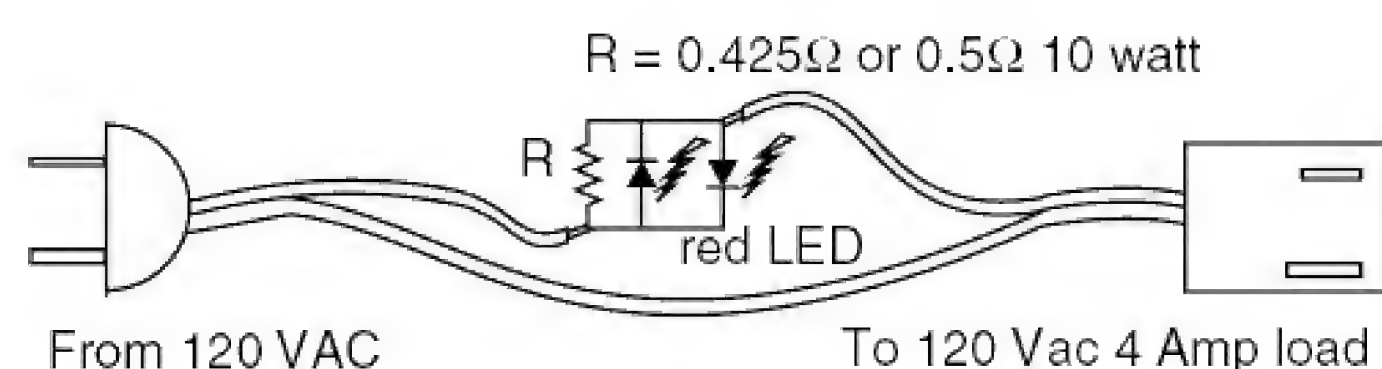
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(1.7 V) than other colors. The closest standard power resistor to the calculated value (0.425 ohm) is a 0.5 ohm 10 watt resistor. You could make this up from multiple parallel, smaller wattage parts. For example, 20 each of 10 ohm half-watt resistors yields a 0.5 ohm 10 watt resistor.

Wire the circuit below in a manner similar to the previous circuit. You may use one LED in this circuit. The LED should light when the load is connected. If not, temporarily disconnect the LEDs and measure the AC voltage across the resistor. Anything less than 1.7 VAC will have trouble lighting the LEDs. A low voltage here indicates that your load is drawing a lot less than four amps, or the resistor is much less than 0.5 ohms. If the LEDs burn out or burn excessively bright, either 1) reduce the value of the 0.5 ohm resistor if made of multiple parallel resistors, or two) put resistance in series with only the LEDs (not the load).



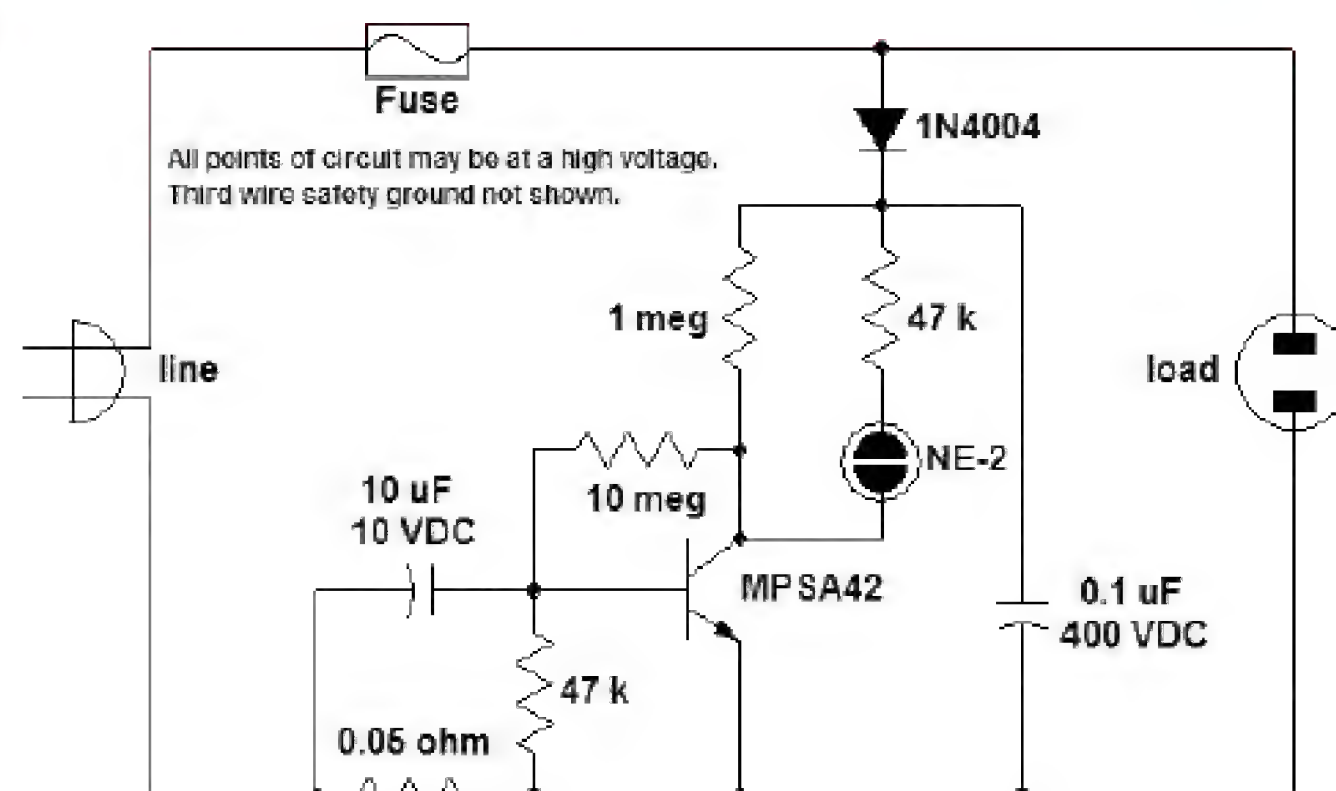
Use the current transformer solution if possible. It wastes little power compared to the 0.5 ohm resistor solution. While both circuits were tested with a 100 watt lamp (0.83 amp) load and different current transformer values, the four-amp version has not been built by the author.

Dennis Crunkilton
Abilene, TX

#3 CR Magnetics makes a current indicator with a built-in LED which illuminates when the current exceeds two amperes. This is a toroid design which is installed by inserting ONE of the current carrying wires through the hole in the center. You can order one online from the manufacturer's website: www.crmagnetics.com/newprod/ProductView.asp?ProdName=CR45

Ron Schafer
Cuyahoga Falls OH

#4 Here is a circuit that will light a neon lamp when your load is drawing four amps when operated from 120 VAC line voltage. The 1N4004 and 0.1 uF capacitor form a 160 VDC power source for the circuit. The high voltage NPN transistor amplifier is biased by the 10 meg resistor and 47 K resistor for a collector voltage near 120 VDC. So, there is about 40 volts across the neon — not enough to turn it on. But when there is current flowing in the sense resistor (0.05 ohms), the transistor amplifies the resulting voltage and the collector swings down sufficiently far to turn on the neon lamp. The high gain of the transistor allows the voltage across the sense resistor to be only a couple of hundred millivolts, keeping the dissipation low. The 47 K



may be adjusted if the collector voltage is too low with no load causing the neon to light. The sense resistor may be varied to change the sensitivity, but keep it low so that it doesn't get too hot. The 0.05 ohm resistor will be dissipating 800 milliwatts at four amps. A length of copper wire will serve as a resistor for this non-precision application, but choose a size that can handle the load current. **Be careful!** All points of this circuit can shock and the circuit must be insulated. Your heater should — no must — be operated from a GFI protected outlet! Use a GFI breaker when testing this at the bench, too.

Charles Wenzel
Austin, TX

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411 Technology Systems88	Command Productions29	Hobby Engineering23	Mouser Electronics45	RABBIT Semiconductor.....35, 45
Abacom Technologies93	Computer Circulation Center85	Industrial Ventures75	Multilabs88	RadioShack21
ActiveWire, Inc.88	Conitec DataSystems30	Information Unlimited53	MVS43	Ramsey Electronics, Inc. ...38-39
Adv. Microcomp. Systems64	Cook's Institute104	Integrated Ideas & Tech., Inc.32	Net Media2	RCG Research25
All Electronics Corp.87	Cunard Associates88	Jameco51, 81	Northwest Technical, Inc.88	RE Smith61
AREXX Engineering41	Custom Computer Services103	Jaycar Electronics65	Parallax, Inc.Back Cover	Scott Edwards Electronics, Inc.11
Atlantic Int'l Institute, Inc.86	Deys Electronics19	LabJack69	PCB123/PCBexpress5	Surplus Sales of Nebraska ...34
Atomic Time.....91	Diskology88	Lemos International Co., Inc.11	PCB Fab Express89	Syspec, Inc.54
AWC78	Earth Computer Technologies93	Link Instruments7	PCB Pool10	Technological Arts102
BalBots.com49	Electronic Design Specialists17	Linx Technologies33	PC-Oscilloscopes/Crag20	Tetsujin 200576
Bellin Dynamic Systems, Inc.88	EMAC, Inc.67	Lynxmotion, Inc.71	Pico Technology Ltd. UK79	Test N Tools18
BitScope Designs31	ExpressPCB27	Madell Technology Corp.12	PolarisUSA Video, Inc.15	Trace Systems, Inc.26
Budget Robotics86	Front Panel Express LLC102	Matco, Inc.88	Pulsar, Inc.88	Windsor Distributors47
C & S Sales, Inc.100	GreenChip13	Maxstream84	QKITS88	XGameStation88
Circuit Specialists, Inc.106-107	Halted Specialties Co.3	microEngineering Labs.....24	R4Systems, Inc.63	Zagros Robotics88
		Micromint95		

AMATEUR RADIO & TV

Atomic Time91	PolarisUSA Video, Inc.15
Ramsey Electronics, Inc.38-39	Surplus Sales of Nebraska ...34
Windsor Distributors47	

BATTERIES/CHARGERS

Cunard Associates88	
---------------------------	--

BUSINESS OPPORTUNITIES

AREXX Engineering41	
---------------------------	--

BUYING ELECTRONIC SURPLUS

Earth Computer Technologies93	GreenChip13	Jaycar Electronics65
-------------------------------------	-------------------	----------------------------

CCD CAMERAS/VIDEO

Circuit Specialists, Inc.106-107	Matco, Inc.88	PCB Fab Express89	PolarisUSA Video, Inc.15	Ramsey Electronics, Inc.38-39
---------------------------------------	--------------------	-------------------------	-------------------------------	------------------------------------

CIRCUIT BOARDS

Advanced Microcomputer Systems, Inc.64	Cunard Associates88	Deys Electronics19	ExpressPCB27	Maxstream84	Micromint95	Northwest Technical, Inc.88	PCB123/PCBexpress5	PCB Fab Express89	PCB Pool10	Pulsar, Inc.88	R4Systems, Inc.63
---	---------------------------	--------------------------	--------------------	-------------------	-------------------	----------------------------------	--------------------------	-------------------------	------------------	---------------------	------------------------

COMPONENTS

Bellin Dynamic Systems, Inc.88	Front Panel Express LLC102	Jameco51, 81	Lemos International Co., Inc.11	Linx Technologies33	Maxstream84	Micromint95	PCB123/PCBexpress5	Pulsar, Inc.88	Windsor Distributors47
-------------------------------------	----------------------------------	--------------------	--------------------------------------	---------------------------	-------------------	-------------------	--------------------------	---------------------	------------------------------

COMPUTER

Hardware	411 Technology Systems88	ActiveWire, Inc.88	Custom Computer Services103	Diskology88	Earth Computer Technologies93	Halted Specialties Co.3	PCB Fab Express89	Surplus Sales of Nebraska34
-----------------	--------------------------------	-------------------------	-----------------------------------	-------------------	-------------------------------------	------------------------------	-------------------------	-----------------------------------

Microcontrollers / I/O Boards	Abacom Technologies.....93	AWC78	Conitec DataSystems.....30	EMAC, Inc.67	microEngineering Labs24	Micromint95	Multilabs88
--------------------------------------	----------------------------	-------------	----------------------------	-------------------	-------------------------------	-------------------	-------------------

DESIGN/ENGINEERING/REPAIR SERVICES

ExpressPCB27	Front Panel Express LLC102	PCB Pool10	Pulsar, Inc.88	R4Systems, Inc.63	Trace Systems, Inc.26
--------------------	----------------------------------	------------------	---------------------	------------------------	----------------------------

EDUCATION

Atlantic Int'l Institute, Inc.86	BalBots.com49	BitScope Designs31	Command Productions29	Cook's Institute104	EMAC, Inc.67	Hobby Engineering23	RCG Research25	Syspec, Inc.54	XGameStation88
---------------------------------------	---------------------	--------------------------	-----------------------------	---------------------------	-------------------	---------------------------	----------------------	---------------------	----------------------

ENCLOSURES

Integrated Ideas & Technologies, Inc.32	
--	--

EVENTS

Tetsujin 200576	
-----------------------	--

KITS & PLANS

AREXX Engineering41	C & S Sales, Inc.100	Custom Computer Services103	Earth Computer Technologies93	EMAC, Inc.67	Hobby Engineering23	Industrial Ventures75	Information Unlimited53	Jaycar Electronics65	Northwest Technical, Inc.88	QKITS88	RABBIT Semiconductor35, 45	RadioShack21	Ramsey Electronics, Inc.38-39	Scott Edwards Electronics, Inc.11	XGameStation88
---------------------------	---------------------------	-----------------------------------	-------------------------------------	-------------------	---------------------------	-----------------------------	-------------------------------	----------------------------	----------------------------------	---------------	----------------------------------	--------------------	------------------------------------	--	----------------------

LASERS

Information Unlimited53	
-------------------------------	--

MISC./ELECTRONICS FOR SALE

RE Smith61	
------------------	--

MISC./SURPLUS

All Electronics Corp.87	Computer Circulation Center85	Front Panel Express LLC102	GreenChip13	Halted Specialties Co.3	Surplus Sales of Nebraska34
------------------------------	-------------------------------------	----------------------------------	-------------------	------------------------------	-----------------------------------

MOTORS

Computer Circulation Center85	Jameco51, 81
-------------------------------------	--------------------

PROGRAMMERS

Conitec DataSystems.....30	microEngineering Labs24
----------------------------	-------------------------------

PUBLICATIONS

Mouser Electronics45	
----------------------------	--

RF TRANSMITTERS/RECEIVERS

Abacom Technologies93	Linx Technologies33	Matco, Inc.88
-----------------------------	---------------------------	--------------------

ROBOTICS

BalBots.com49	BitScope Designs31	Budget Robotics86	Hobby Engineering23	Jameco51, 81	LabJack69	Lemos International Co., Inc.11	Lynxmotion, Inc.71	Net Media2	RadioShack21	Zagros Robotics88
---------------------	--------------------------	-------------------------	---------------------------	--------------------	-----------------	--------------------------------------	-------------------------	------------------	--------------------	-------------------------

SATELLITE

Lemos International Co., Inc.11	
--------------------------------------	--

SECURITY

Computer Circulation Center85	Information Unlimited53	Linx Technologies33	Matco, Inc.88	PolarisUSA Video, Inc.15
-------------------------------------	-------------------------------	---------------------------	--------------------	-------------------------------

TEST EQUIPMENT

Bellin Dynamic Systems, Inc.88	BitScope Designs31	C & S Sales, Inc.100	Circuit Specialists, Inc.106-107	Conitec DataSystems.....30	Electronic Design Specialists17	Jaycar Electronics65	LabJack69	Link Instruments7	Madell Technology Corp.12	PC-Oscilloscopes/Crag20	Pico Technology Ltd. UK79	Test N Tools18	Trace Systems, Inc.26	Syspec, Inc.54
-------------------------------------	--------------------------	---------------------------	---------------------------------------	----------------------------	---------------------------------------	----------------------------	-----------------	-------------------------	--------------------------------	-------------------------------	---------------------------------	----------------------	----------------------------	---------------------

TOOLS

C & S Sales, Inc.100	Madell Technology Corp.12
---------------------------	--------------------------------







VIDEO

Multilabs88	
-------------------	--




WIRE/CABLE & CONNECTORS

Jameco51, 81	
--------------------	--

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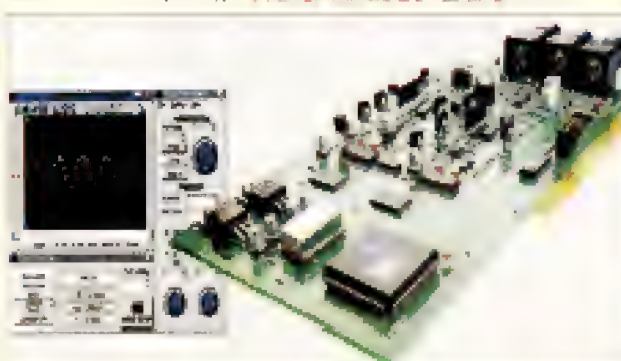
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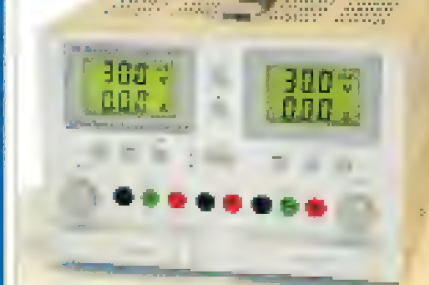
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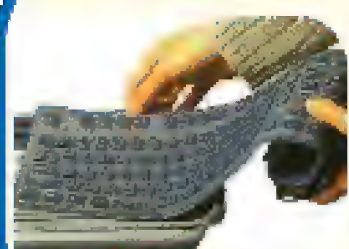
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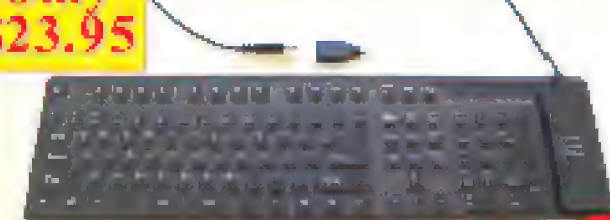
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in error by one part in 5,000 or so. If you don't need an inductance meter, you can use the PIC plus an LCD as a compact 1 MHz frequency meter. Of course, if you only want an inductance meter, you can leave out the BNC connector and the L/F switch.

Self-ranging

When measuring inductance, the input frequency lies somewhere in a 100:1 range. Using a short counting period would result in loss of resolution at the low end of the range, while a longer period would lead to a total count greater than two bytes. I compromised by dividing the frequency range into high and low decades. The easiest way to achieve this was to use two counting periods, 40 mS and 400 mS. If the 40 mS count is greater than 2,765, it's processed as-is. Otherwise, a 400 mS count is done and a factor of 100 is incorporated into the inductance display.

Counting Loops

The timing loop has to perform two tasks: to keep track of how many instructions have been executed and to look for overflows from the PIC's timer register, RTCC. With a times-two prescaler, the RTCC register overflows

every 512 input pulses. We must read it more often than that and increment a carry register any time RTCC shows a decrease from its last state, that is, if an overflow has taken place. The sampling and updating loop executes once per 256 instructions and repeats every 166.7 μ S.

A further counting loop executes 60 of these 256 instruction sampling cycles and thus repeats every 10 mS. Its loop counter is preset to 4, 40, or 200 to give 40 mS, 400 mS, or 2 S periods.

When nesting loops this way, put several NOPs at the start of the inner loop. After N times around the inner loop, it's time to decrement the outer loop, to reload N, and start the inner loop cycling again. This takes five or so extra instructions. You play catch-up by jumping into the inner loop below the NOPs, making the first cycle shorter than a regular one.

Computing the Answer

Commercial inductors generally have 10% tolerances. Except when comparing matched inductors, there's little point in making very accurate measurements. A three-digit indication in mH or μ H units is perfectly adequate. The nominal range is from 10.0 μ H to 99.9 mH. The display indicates when the inductor is too high or too low to measure.

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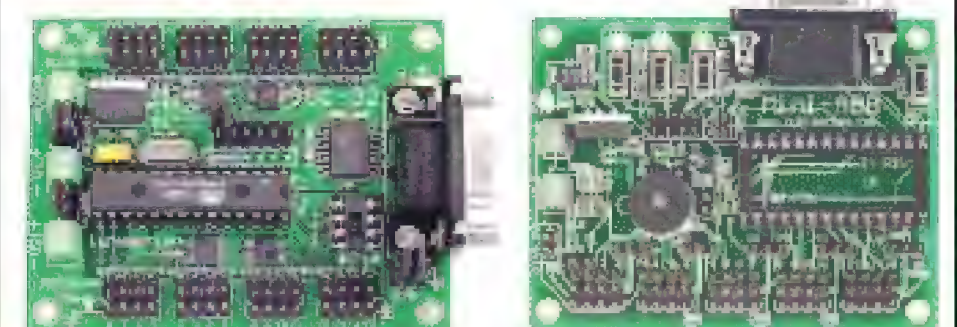
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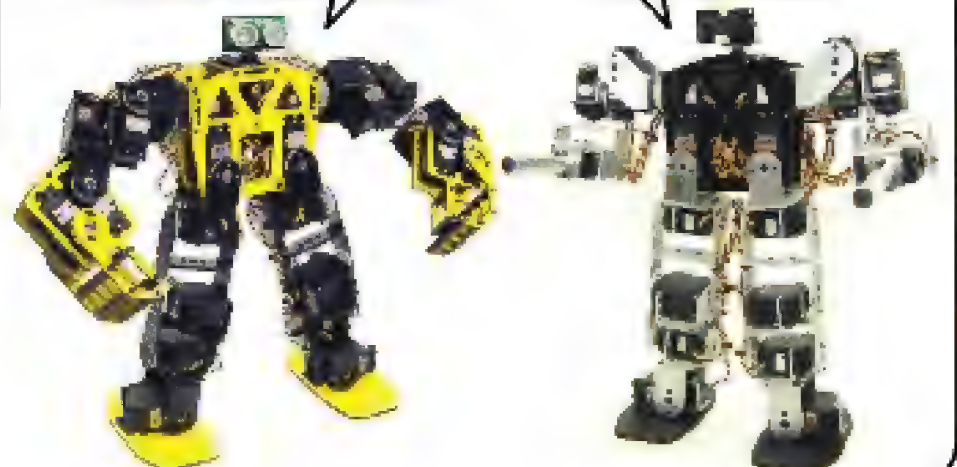


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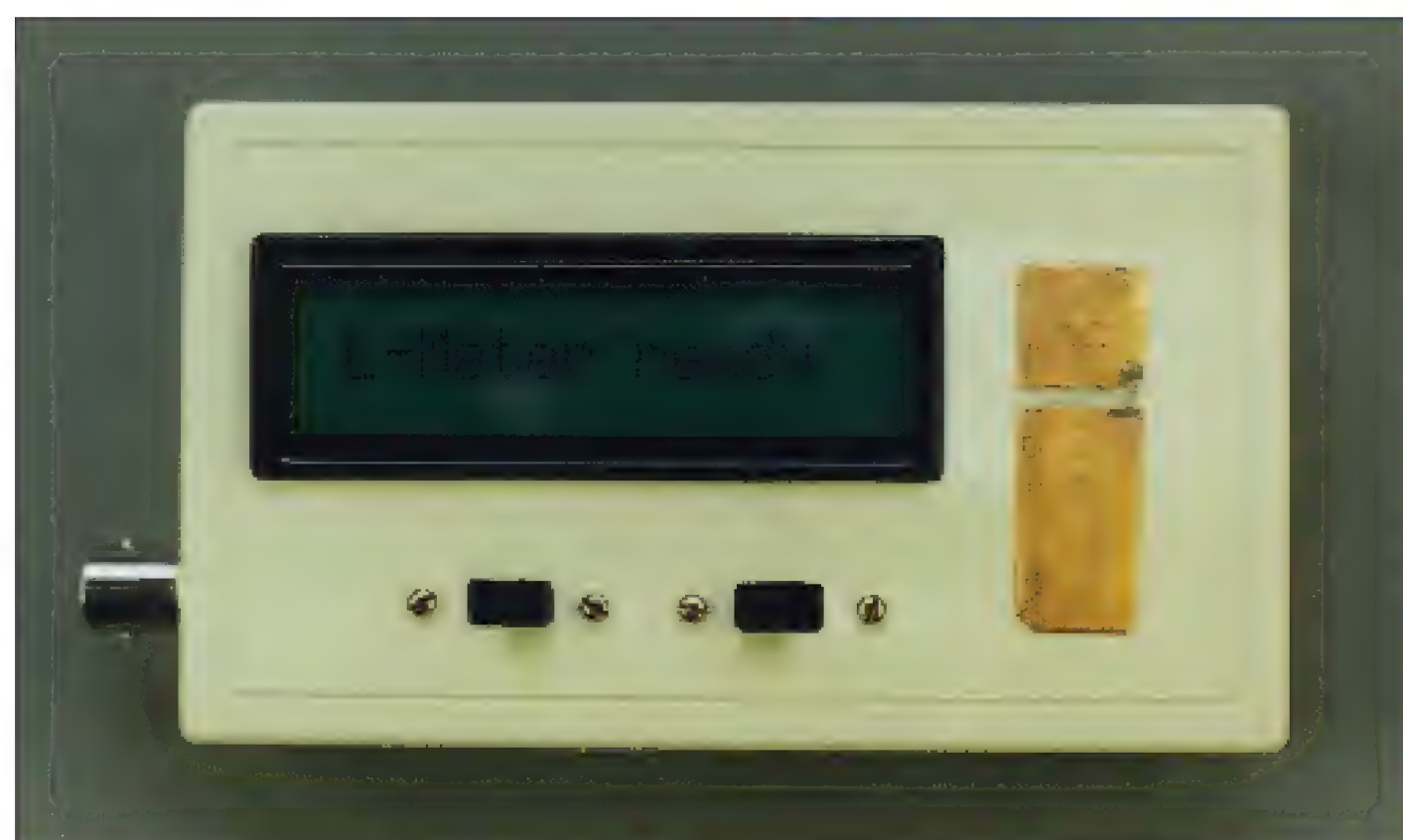


Figure 3. I decided not to spoil the meter's elegant simplicity with clumsy labels. The display tells you that the meter is on and what mode it is in.

To convert a frequency to an inductance, a three-byte calibration constant is divided by the frequency and the result is squared. This is then converted to decimal form for the display. This process has to work on numbers from 3,000 to 30,000 without overflowing or losing resolution.

The constant is multiplied by 256 before being divided by the 16-bit count. The 16-bit result is squared, giving a 32-bit number whose lower two bytes are ignored. This corresponds to the inductance in units of 0.1 μ H or 0.01 mH, depending on the range. This is converted into a four-digit BCD string whose first three non-zero digits drive the display. Luckily, 32 by 16 bit division, 16 by 16 multiplication, and BCD conversion are library functions I've used many times.

Powering It

This oscillator (and some LCDs) requires a negative power rail. A negative three-terminal regulator derives

Picking a PIC

The Microchip PIC16C5x series of low-level microcontrollers come in 18 and 28 pin packages and offer a range of both program (EPROM) memory and register (RAM) memory. They are available in erasable versions having a ceramic package with a UV transparent window and in one-time-programmable (OTP) plastic packages that can only be programmed once. For amateurs, the ability of the windowed parts to be erased and reprogrammed far outweighs their higher price-tag. The UV erasable part is 16C54C/JW.

Recent 16C5x revisions are not only cheaper, they run twice as fast as their predecessors, up to 40 MHz rather than the original 20 MHz. This project needs just less than the minimum available code and register space, so even the humblest of 16C54 chips will do the job. It won't hurt to use a 16C56 or 16C58 and the revision level doesn't matter. This is a great way to reuse any old, slow PICs you have lying around.

The PIC must be programmed with the code LMETER.OBJ (INHX8M format) which is available from Nuts & Volts website's FTP library (www.nutsvolts.com).

both positive and negative supplies from a nine-volt battery. The positive (+5 V) rail that drives the PIC is the battery's positive terminal. Its negative terminal supplies about -4 V to the oscillator. For convenience, I used a 79L05 regulator. This has the disadvantage of 3 mA stand-by current. You can save some battery power by substituting a low-power negative regulator for the 79L05. The battery consumption is about 7.5 mA, so you can expect a battery life in the 50 to 100 hour region.

One PIC port acts as a go/no-go battery voltage sensor. A "Battery Low" message is displayed when the battery voltage — about 7.5 V — is too low to maintain a regulated five-volt supply.

Packing it In

One has the usual options. Shoe-horn everything into the minimum plastic case possible or use a bigger box that takes up more space on the bench-top. I went for the first option even though it required more design work. My meter is wedged into the 4.5" by 2.7" box shown in Figure 3.

The display cut-out allows the bezel to protrude, letting the display board lie against the inner surface of the box and be glued to it with some silicone rubber. This leaves more height for the other components.

I filed the inner edges of the pillars which hold the box together to mount the LCD a little closer to the edge of the box. One edge of the LCD board protrudes into the battery compartment but doesn't get in the way. This edge could be trimmed off if necessary. (You might be more comfortable using a larger box.)

The circuit board is mounted behind the display. My display had its connector pads in its top left corner. This dictated the layout of the front panel and the size of the circuit board. I had to bend some of my design rules to make things fit. Figure 4 shows the result.

The primary mechanical support for the board is the row of wire-wrap pins I soldered to it. They mate with a female connector soldered to the LCD. Soldering both ends of the pins is an alternative. Pins on the lower edge of the board add rigidity and, incidentally, couple the test pads and the battery to the board. Since only connector friction holds the board in place, I glued some foam draft-excluder tape to the bottom of the box to stop the board from working loose.

The contact pads for the inductor under test are a piece of very thin single-sided PC board glued to the front panel over the battery compartment. I cut away some of the insulating material with a dental drill to make invisible connections to the undersides of the pads. In the ideal world, the pads would be gold-plated and the battery would be shielded from the "live" pad to eliminate its stray capacitance.

Apart from the display, the only other front-panel features are the two slide switches. One turns the meter on and off, the other selects frequency or inductance mode. VR1, a

trimmer on the PC board, sets the contrast of the LCD.

Board Construction

I rarely use printed circuits for prototypes, preferring perforated prototyping board with continuous copper strips on one side. I cut a board 1.5" by 2.9" with the copper strips parallel to the short side of the board. The strips are cut as necessary. Bus-wires are added on the component side before the components are inserted. This makes for a neat layout and is far easier than etching a custom printed circuit. Figure 5, which can be viewed at the *Nuts & Volts* website (www.nutsvolts.com), shows the component side of the board. Pairs of short parallel lines indicate where a copper strip on the underside must be cut through. The thick horizontal lines represent bus wires. Diamonds show where these are soldered to the copper strips.

Unfortunately, I couldn't quite squeeze in all the components. C5 is wired between other components, the leads of R5 must be bent inwards before soldering, and R7 has to bend around a jumper wire.

Finding a Display

Two good sources of cheap displays are All

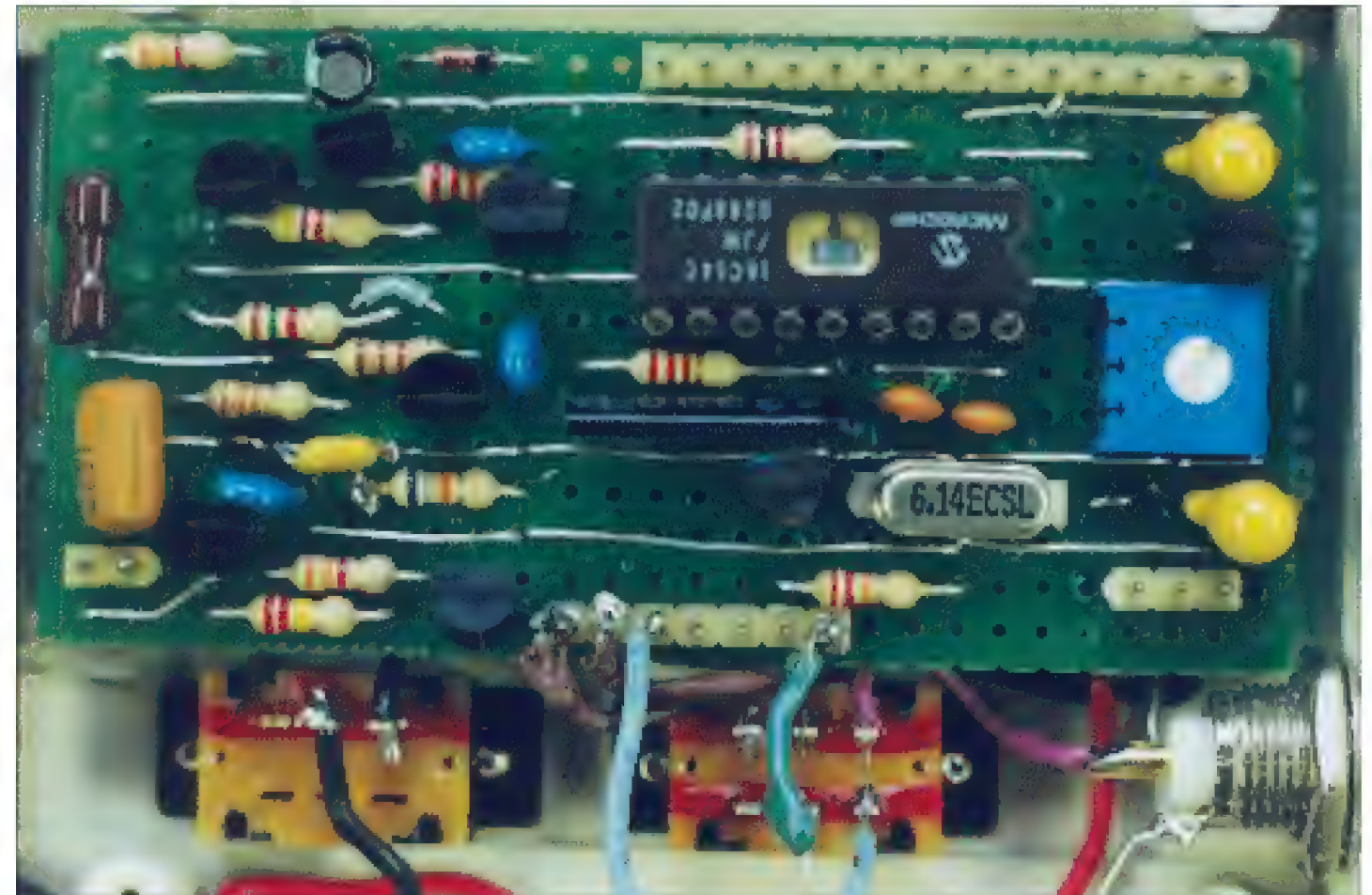


Figure 4. If the 1.5" by 2.9" circuit board is mounted directly on the display, the entire unit fits in a 2.7" by 4.5" project box.

Electronics (www.allelectronics.com) and Marlin P. Jones & Association (www.mpja.com). You need a one-line by 16-character display. The description may not specifically say "reflective," but that's the kind you want. If "transmissive" or "backlight" are mentioned, you're looking at the wrong type, it won't run from a battery.

No particular display is guaranteed to remain in stock.

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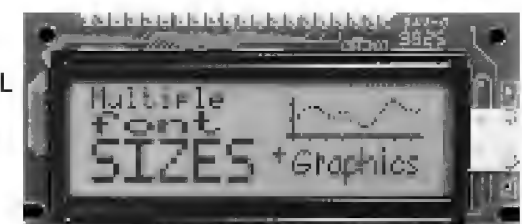
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I used the LCD-75 from All Electronics but by the time you read this, they may have some other 16-character displays in stock. As these are around \$5.00 each, you can probably afford to experiment.

Not all displays use the same pinout. The standard I've assumed is a 14-pin single row on a long edge of the board. One snag is that, in some displays, the connector pads run along the bottom edge of the board and in others, the top edge. Often you can't tell which is which without powering up the display. The one I bought had its connector above the display even though the lettering on the PC board implied that the display should be mounted the other way up.

Check which pad is number 1. It's the ground pad

Parts List

U1	79L05	Negative voltage regulator
U2	PIC16C54C/JW	See sidebar
Q1, Q3, Q6, Q7	NPN transistor, 2N3904	
Q2, Q4, Q5	PNP transistor, 2N3906	
D1	Small signal diode, 1N4448 or similar	
X1	6.144 MHz crystal. (e.g., Digi-Key type X414)	

All resistors 5%, 0.25W

R1	220K
R2	3.3K
R3	33K
R4	68K
R5	3.3K
R6	4.7K
R7	1.5K
R8	2.2K
R9	22K
R10	1.2K
R11	1.0K
R12	22K

VR1	10K trimmer
SIP	Six-pin 33K, common connection to pin 1

C1	0.01 uF 5%, plastic foil
C2	1500 pF 1%, mica or plastic foil
C3, C4, C5, C6	0, 1 uF 20%, ceramic
C7	10 uF 16V, electrolytic
C8, C9	15 uF 20V, tantalum bead
C10, C11	33 pF, ceramic

SW1	On/Off slide switch
SW2	Two-pole, two-way slide switch

LCD	One line by 16 character reflective display
-----	---

Plastic project box
Prototyping board (e.g., All Electronics #ECS-4)
Male and female single line connectors
BNC connector

and is connected to the bezel of the display. If it's at the "wrong" end of the row, the meter board must be mounted upside-down to make the pins match. Reflective displays sometimes come with two extra pads (15 and 16) to drive the non-existent backlight. These can be ignored.

The other common connector standard is a double row of pads on the short edge. This makes for a convenient ribbon cable interface but such a display would be too long to fit the box.

In my experience, 16-character, single-line displays behave electrically as if they were eight-character, two-line displays. That is, they use two separate sections of display memory to store the first and second eight-character block. (This minimizes driver chips.) The PIC firmware takes this into account but offers the option of writing all 16 characters to a single block, letting you use one line of a two-line display as your output device. A jumper wire between the pins labelled DM and G in Figure 5 sets this mode of operation.

Calibration

The relationship between the oscillator frequency and the displayed inductance is controlled by a calibration constant stored as three RET N instructions at code addresses 1, 2, and 3. The default value is 277,578 which corresponds to a tuning capacitance of 1,315 pF (C1, C2 and 11 pF of stray capacitance). If the strays are significantly higher, or if you measure large air-cored inductors with a high self-capacitance, the oscillator frequency will be lower than it should be and the meter will read high. If, when measuring accurately-known inductors, you get readings more than a percent or two in error, you might consider changing the calibration constant. If your meter gives consistently low inductance readings, this can be corrected by adding a 30 pF trimmer across the 1,500 pF capacitor.

This meter measures inductance under small-signal conditions. It has no mechanism for measuring how core saturation affects the inductance at high operating currents. Saturation is an important factor in DC-DC converter design.

Pleased as L

After years of fumbling with capacitors and signal generators, it's extremely gratifying to be able to touch any old inductor to the contact pads and have the meter tell me its value. I hope you'll find it as useful as I do. **NV**

About the Author

Tom Napier formerly worked for space and high-energy physics research organizations in Europe. Since 1982, he has developed innovative electronic equipment for companies in the US. He is now an electronics consultant based in SE Pennsylvania.

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Stepper Motor, 12VDC 50 OHM
HSC#20264 \$2.95



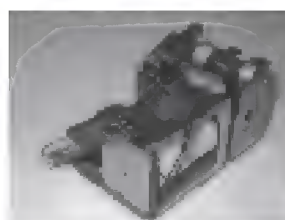
Solenoid, 5VDC, 150 mA
HSC#19606 \$2.95



Peltier Cooling Module
HSC#CAP052 \$14.95



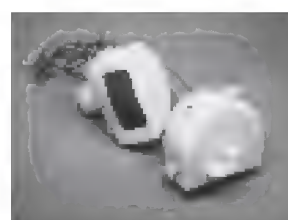
Motor, 24VDC, 250 Oz/in. Torque
HSC#20452 \$29.50



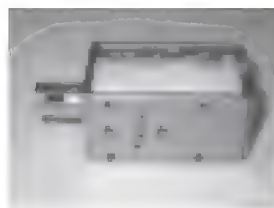
Solenoid with Opto-Sensor
HSC#19362 \$6.95



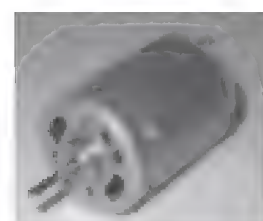
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DC Motors with rubber tire (pair)
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HSC#WEL021 \$39.00



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HSC#18911 \$4.50



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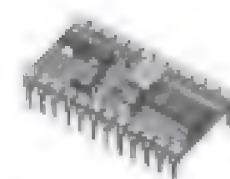
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- ♦ No software, docs, get it off the net!

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- ♦ Regulated output 12 VDC at 2.0 A

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- ♦ Regulated output 24 VDC at 1.67 A

HSC#20550 \$14.95



The MIDI-nator

Control Instruments on the Road with this Interface

I have been a fan of MIDI (Musical Instrument Digital Interface) since the 1980s. The idea of controlling musical instruments from a computer has always seemed cool to me. Over the years, I have owned a number of MIDI cards and interfaces for my computers. I finally got around to buying a notebook computer. One of the characteristics of the new portable was the lack of a classic parallel port or card slot. The general trend on new computers is the replacement of the classic serial and parallel ports with Universal Serial Bus (USB) ports. With the elimination of the classical ports and card slots, I lost my MIDI interface capability. Thus was born the USB to MIDI interface project – the MIDI-nator. With this project, I will give the portable computer the ability to control musical instruments.

A Brief Introduction to USB

The USB 2.0 specification (Reference 1) supports three data transfer rates: high at 480 million bits per second (Mbps), full at 12 Mbps, and low at 1.5 Mbps. USB allows peripherals to be plugged and unplugged without down-powering the computer. This process, called “enumeration,” involves communicating with the peripheral to discover the identity of the device driver that should be loaded. A unique address is assigned to each peripheral during enumeration to be used for run-time transfers. During run-time, the host PC initiates transactions to specific peripherals, and each peripheral accepts its

transactions and responds accordingly.

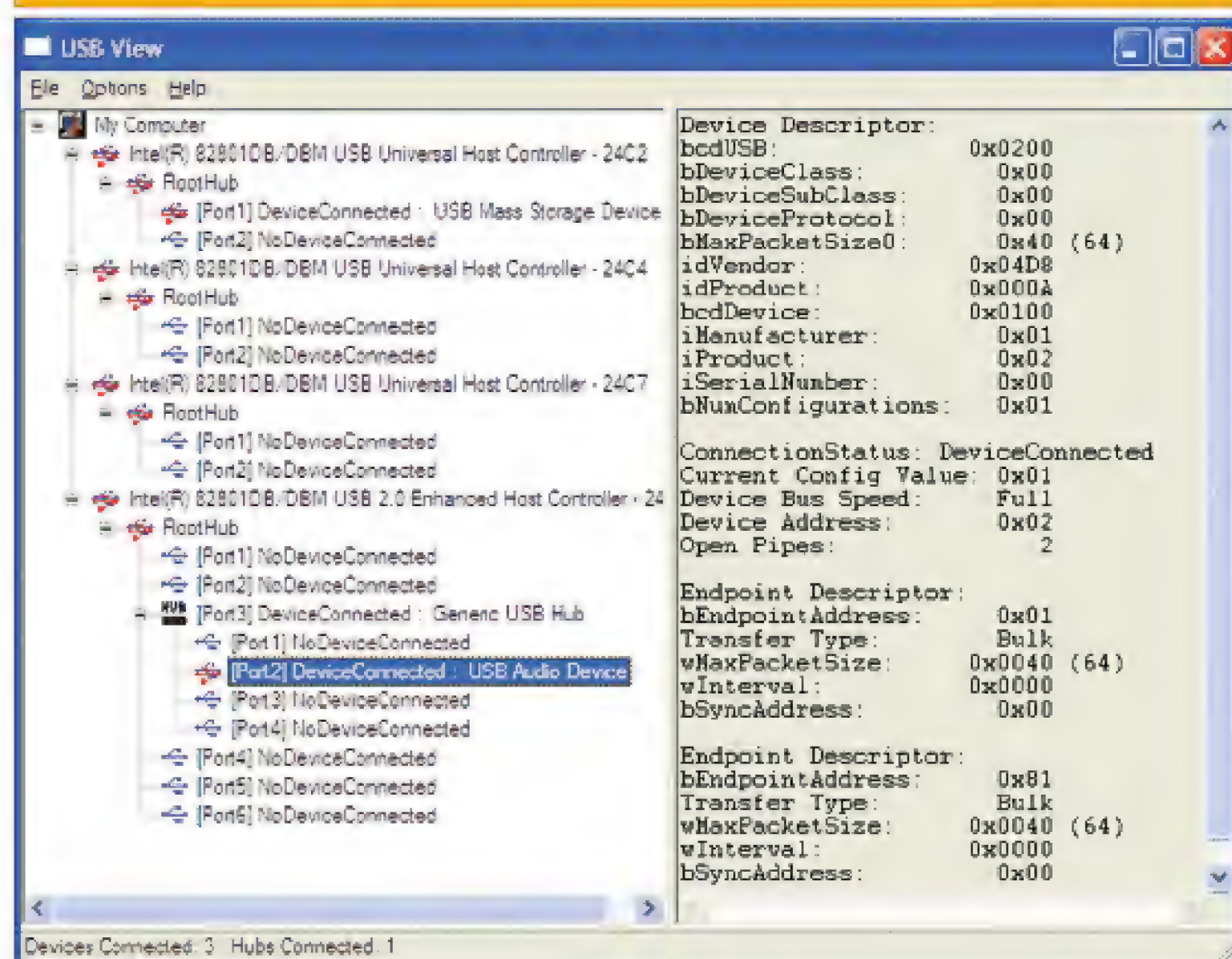
From the peripheral point of view, all USB peripherals are slaves that obey a defined protocol. They must react to request transactions sent from the host PC. The peripheral responds to control transactions that, for example, request detailed information about the device and its configuration. The peripheral sends and receives data to/from the host using a standard USB data format.

USB 2.0 supports four types of data transfers: Control, Bulk, Interrupt, and Isochronous. Control transfers are bursty, non-periodic, host software-initiated request/response communications, typically used for command/status operations. Bulk transfers are non-periodic, large-packet bursty communications, typically used for data that can use any available bandwidth and can also be delayed until bandwidth is available. Bulk transfers perform error detection via CRC.

I will use control transfers during the enumeration process and bulk transfers for the MIDI data. It is important to note that bulk transfers include error checking and retry capability but no guaranteed delivery latency. Thus, it is possible for MIDI data to be slightly delayed if your other USB devices are extremely busy.

Microsoft has a tool available for examining the USB ports. USBView is a free utility from Microsoft (Source 1) that displays the USB connection tree and shows details of the USB devices that are connected to it, as shown in Figure 1. This is very useful for debugging USB enumeration errors. USBView runs under Windows 98/ME/2000/XP. USB ports transfer data through ENDPOINTS which are analogous to buffers.

Figure 1. USBVIEW of MIDI-nator.



The Microprocessor

The PIC18F2455 is one of the new USB enabled Flash memory microprocessors from Microchip. The 24K bytes of Flash program memory allow the user to store about 12 thousand 16-bit instructions which can be erased and reprogrammed electronically. The Flash program memory supports 100,000 write/erase cycles and has a greater than 40 year retention period. The microprocessor has 2048 bytes of RAM data memory. The microprocessor has many of the features users have come to expect from Microchip: Universal Asynchronous Receiver/Transmitter (UART) module, four timers, 10 10-bit A/D channels, and a master synchronous serial port (MSSP). The MSSP is useful for communicating with peripheral devices such as serial

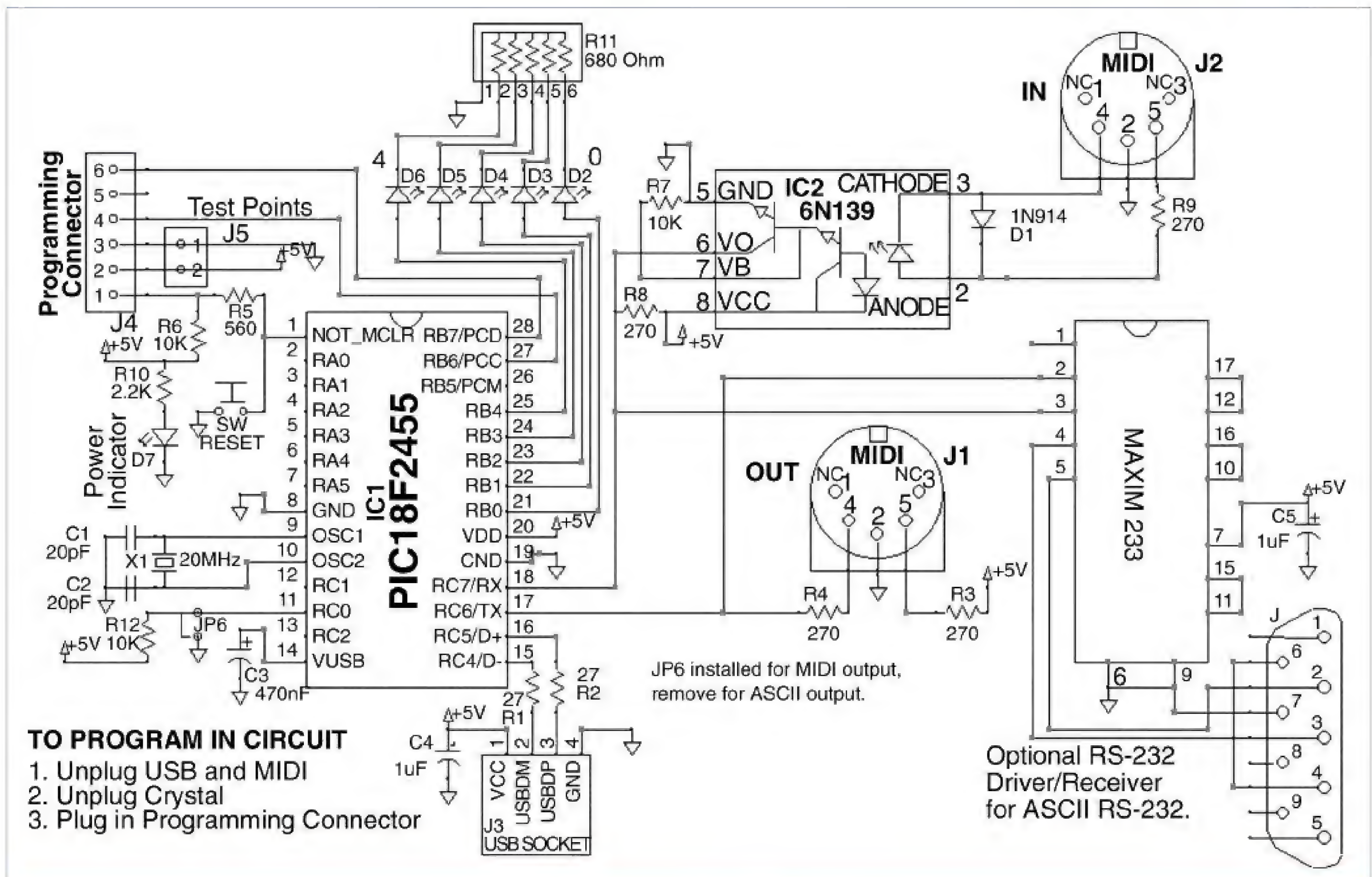


Figure 2. USB to MIDI Interface Schematic.

EEPROMS and supports SPI and I2C protocols. The PIC18F2455 has 75 base instructions and offers seven different operating modes for managing power consumption.

The USB engine is V2.0 compliant and operates at low (1.5 Mb/sec) and full (12Mb/sec) speeds. The USB engine supports all types of data transfers and up to 32 endpoints. It has one kilobyte of RAM starting at 400h that is shared between the CPU and the USB engine. This shared memory can be configured for optimum use by the user. The first few locations are defined in umidi.h and are used for endpoint (buffer) descriptors: BDnSTAT, BDnCNT, and BDnADR. The locations are defined by how many of the endpoints use dual (ping-pong) buffering. BDnSTAT is the status register for the nth endpoint. Bit 7 determines who owns the buffer (CPU or USB engine) and who can write to it. BDnCNT is the number of bytes in the buffer. BDnADR is the integer where the buffer starts in the 400h-7FFh range. The PIC18F2455 supports a dual buffering scheme in which case each endpoint has two buffers defined. Up to a total of 64 buffers can be defined.

Building the Hardware

The circuit for the USB to MIDI interface is fairly simple and is shown in Figure 2. The connections are few

enough that it can be built on a 2" by 4.5" prototype board having hole spacings at 0.1". Figure 3 shows the layout of the components on the board, and can be viewed at the *Nuts & Volts* website (www.nutsvolts.com). Component side jumpers are shown in red. The heart of the system is the programmed PIC18F2455 that handles the USB proto-

References

- Reference 1 — Universal Serial Bus Revision 2.0 Specification at www.usb.org/developers/docs/
- Reference 2 — MIDI Manufacturer's Association at www.midi.org
- Reference 3 — USB Device Class Definition for MIDI Devices at www.usb.org/developers/devclass_docs/midi10.pdf
- Reference 4 — Programming the Microsoft Windows Driver Model by Walter Oney
- Reference 5 — Microsoft MSDN Library at http://msdn.microsoft.com/library/default.asp?url=/library/enus/stream/hh/stream/aud-design_2951b252-9b80-4b59-82de-bce22fd1203e.xml.asp
- Reference 6 — PIC18F2XX0/2XX5/4XX0/4XX5 Flash Microcontroller Programming Specification from www.microchip.com

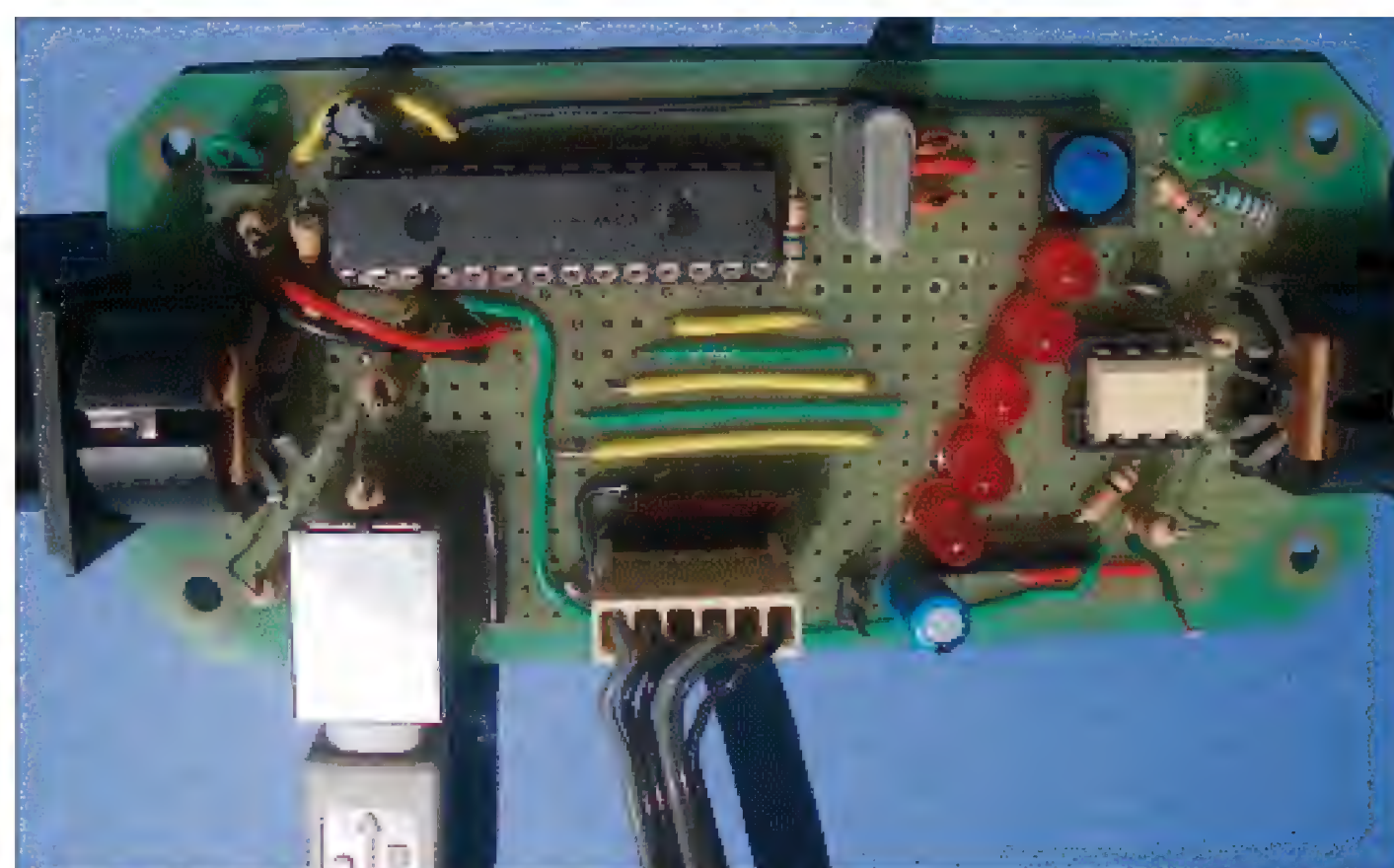


Figure 4. Completed MIDI-nator Prototype Board.

col and MIDI serial input and output. Preprogrammed PIC18F2455 chips can be obtained from Source 2. The MIDI input is optically isolated from the microprocessor by a 6N139 high speed, high gain Darlington optoisolator.

There are five LEDs that are used to announce the state of the microprocessor and a power LED. A 20 MHz

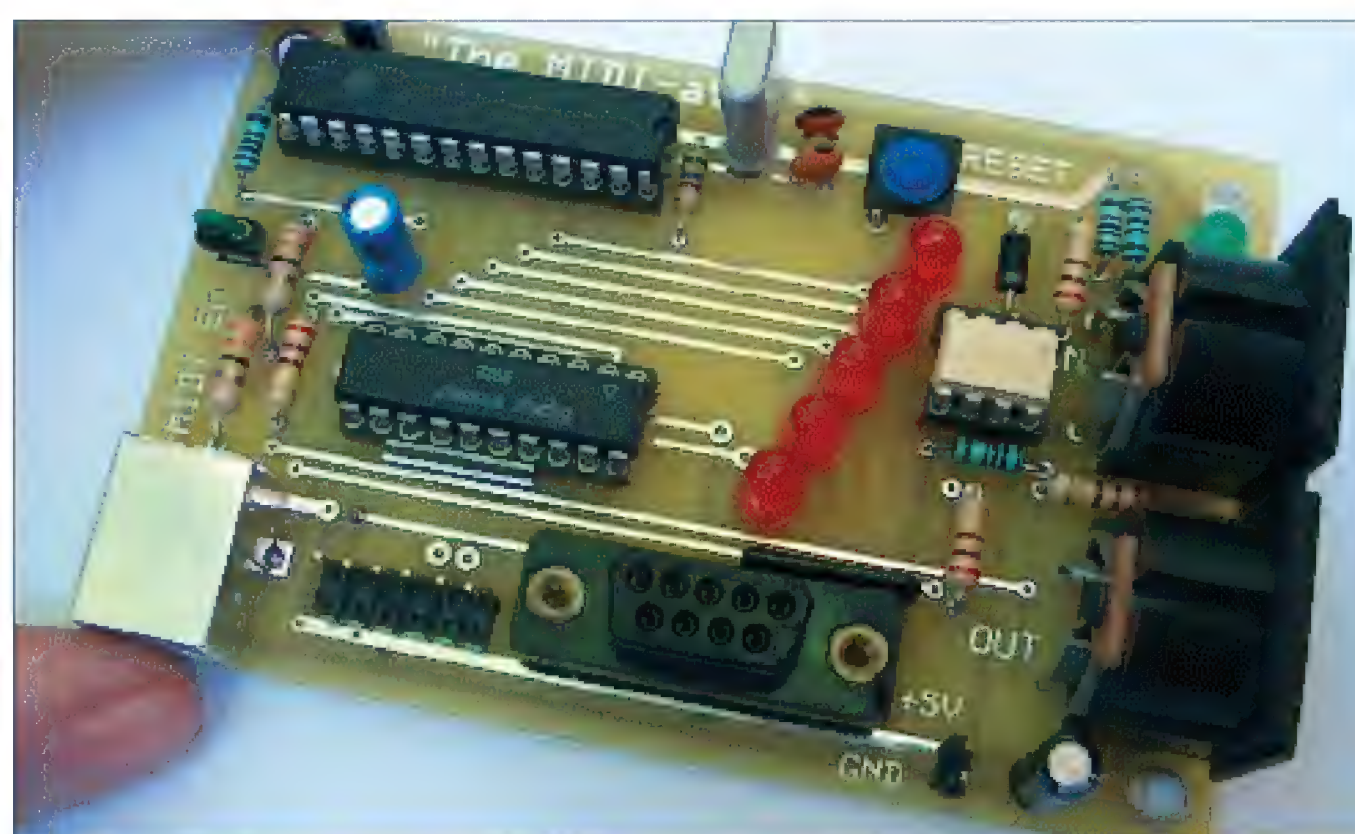


Figure 5. MIDI-nator using Printed Circuit Board (with optional RS-232 debug output).

crystal oscillator provides the clock for the system and a manual pushbutton is used to reset the system. There is a programming connector used to bring programming signals from the programmer to allow in-circuit programming of the PIC18F2455. Two MIDI connectors and a USB connector complete the hardware. Power is provided

through the USB connector. The completed circuit board is shown in Figure 4. For the initial debugging, I added an optional Maxim 233 RS-232 driver/receiver. This allowed me to send debugging data to be printed on the PC at 115,200 baud. Table 1 gives the parts list for building the USB MIDI interface board.

If you do not want to tackle building the device from scratch on a prototype board, a printed circuit board is available at Source 2. The completed device on the printed circuit board is shown in Figure 5. The printed circuit board includes connections for the optional RS-232 debug feature.

MIDI Description

The MIDI enables people to use multimedia computers and electronic musical instruments to create, enjoy, and learn about music. There are actually three components to MIDI. The components are the communications Protocol (language), the Connector (hardware interface), and the distribution format called Standard MIDI Files.

I will discuss only the MIDI serial protocol in this article. The MIDI protocol is an entire music descrip-

Quantity	Part ID	Description	Source #	Part #	Cost Each
1	J3	USB B PCB connector	Source 5	230957	\$.99
1	PCB	Prototype circuit board Printed circuit board	Source 5 Source 2	105128	\$7.95
1	SW	Reset switch (momentary contact)	Source 5	162886	\$.45
1	R11	Resistor net, 6 pin, 680 ohm	Source 5	267872	\$.14
1	X1	20 MHz crystal	Source 5	14517	\$.79
2	C1, C2	20 pF disk capacitor	Source 5	15405	\$.07
1	C3	470 nF electrolytic capacitor	Source 5	158481	\$.05
2	C4, C5	1 uF electrolytic capacitor	Source 5	158490	\$.06
2	R1, R2	27 ohm resistor [1]	Source 5	30584	100 for \$1.00
4	R7, R3, R4, R8	270 ohm resistor	Source 5	30605	100 for \$1.00
1	R5	560 ohm resistor	Source 5	31376	100 for \$1.00
1	R6, R12	10K ohm resistor	Source 5	29911	100 for \$1.00
1	R10	2.2K ohm resistor	Source 5	30314	100 for \$1.00
1	D2-D7	LEDs	Source 5	206498	\$.15
1	J4, J5	Test points and programming connector	Source 5	103392	\$.18
1	IC1	PIC18F2455 microprocessor Preprogrammed available	Source 6 Source 2	—	\$7.76
1 optional	IC3	Maxim233 RS-232 driver/rec (debugging)	Source 5	106163	\$5.75
1 optional	J6	9 pin RS-232 female connector	Source 5	15780	\$.55
1	IC2	6N139 optical isolator	Source 5	113929	\$.65
2	J1, J2	5 pin DIN socket	Source 5	29399	\$.59
1	D1	1N914 diode	Source 5	179207	\$.05
		[1] All resistors 1/4 watt			

Table 1. USB MIDI Interface Parts List.

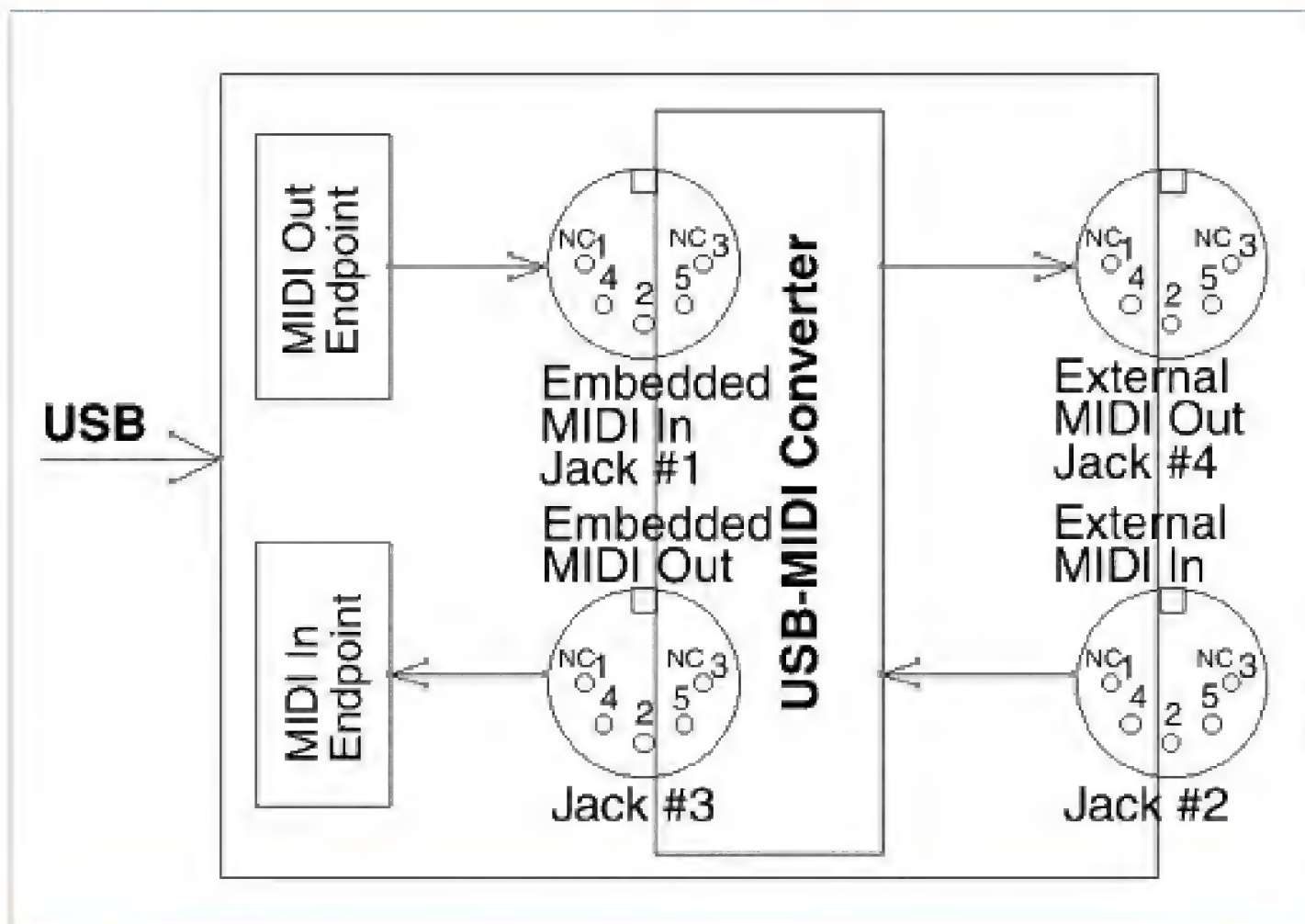


Figure 6. Simple USB-MIDI Interface.

tion language in binary form. Each word describing an action of musical performance is assigned a specific binary code. MIDI was designed for keyboards, so many of the actions are percussion-oriented. To sound a note in MIDI language, you send a "Note On" message, and then assign that note a "velocity," which determines how loud it plays. Other MIDI messages include selecting which instrument to play, mixing and panning sounds, and controlling various aspects of electronic musical instruments. Table 2 gives a list of some of the MIDI status and data bytes. Notice that the status bytes and data bytes are differentiated by whether the high order bit is set or not. A complete list and description of the MIDI messages are given in Reference 2.

The characteristics of the MIDI serial protocol are that data is transmitted at a rate of 31,250 bits per second, there is one start bit and one stop bit, and the voltage levels are 0 and +5 volts. The PIC18F2455's built-in UART can be used to send and receive MIDI data as long as these characteristics are met.

USB Device Class Definition for MIDI Devices

The USB organization has defined the way MIDI data is transmitted over the USB connection in the USB Device Class for MIDI Devices (Reference 3). In the USB MIDI class, the MIDI data is sent in four-byte event packets as shown in Table 3. The USB-MIDI event packet provides a wrapper around a standard serial

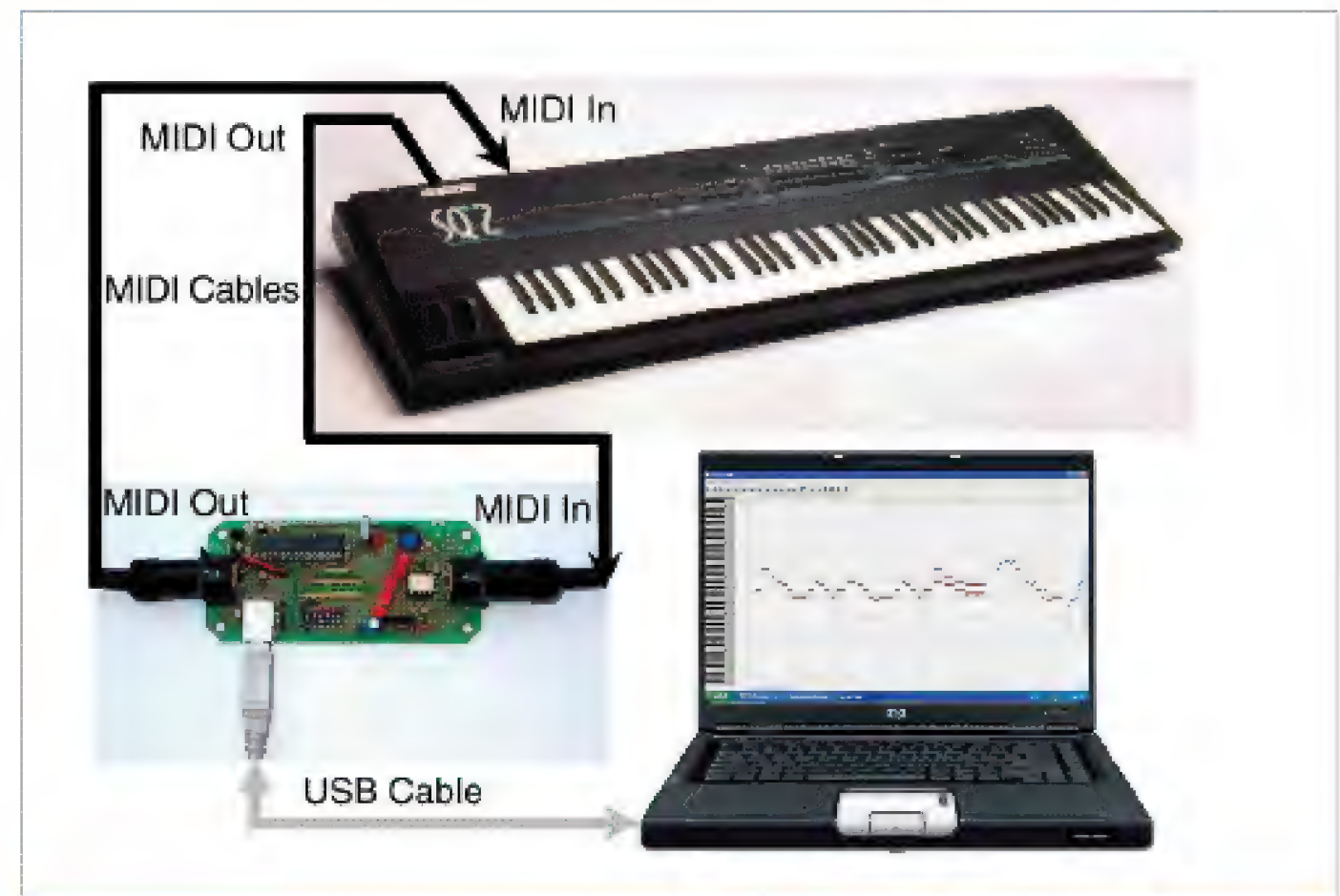


Figure 7. MIDI-nator Hookup Diagram.

MIDI command. New information is also added. The cable number is a value ranging from 0 to Fh.

The Code Index Number indicates the type of MIDI command that has been wrapped. In many cases, it is the same as the MIDI command. Perhaps an example would be useful. The standard MIDI command for a NOTEON of middle C on channel 0 with a velocity of 100 is 90 40 64 in hex. The corresponding USB-MIDI event packet for MIDI cable 1 is 19 90 40 64. It is the task of the USB-MIDI output device to receive the event packet from the personal computer (PC) via USB, decode it, and send the MIDI command

Status D7-----D0	Data Byte(s) D7-----D0	Description
1000nnnn	0kkkkkkk 0vvvvvvv	Note Off event. This message is sent when a note is released (ended). (kkkkkkkk) is the key (note) number. (vvvvvvv) is the velocity. (nnnn) = 0-15 (MIDI Channel Number 1-16).
1001nnnn	0kkkkkkk 0vvvvvvv	Note On event. This message is sent when a note is depressed (start). n, k, and v defined as above.
1011nnnn	0ccccccc 0vvvvvvv	Control Change. This message is sent when a controller value changes. Controllers include devices such as pedals and levers. (ccccccc) is the controller number. (vvvvvvv) is the new value (0-119).
1100nnnn	0pppppppp	Program Change. This message is sent when the patch number (instrument) changes. (pppppppp) is the new program number.
1110nnnn	01111111 0mmmmmmm	Pitch Wheel Change. This message is sent to indicate a change in the pitch wheel. The pitch wheel is measured by a 14 bit value. Center (no pitch change) is 2,000H. Sensitivity is a function of the transmitter. (1111111) are the least significant seven bits. (mmmmmmm) are the most significant seven bits.

There are many other MIDI commands. For a complete list, see Reference 2.

Table 2. MIDI Commands.

Byte 0	Byte 1	Byte 2	Byte 3
Cable #	Code Index #	MIDI status byte	MIDI data byte #1 MIDI data byte #2

Table 3. 32-bit USB-MIDI Event Packet.

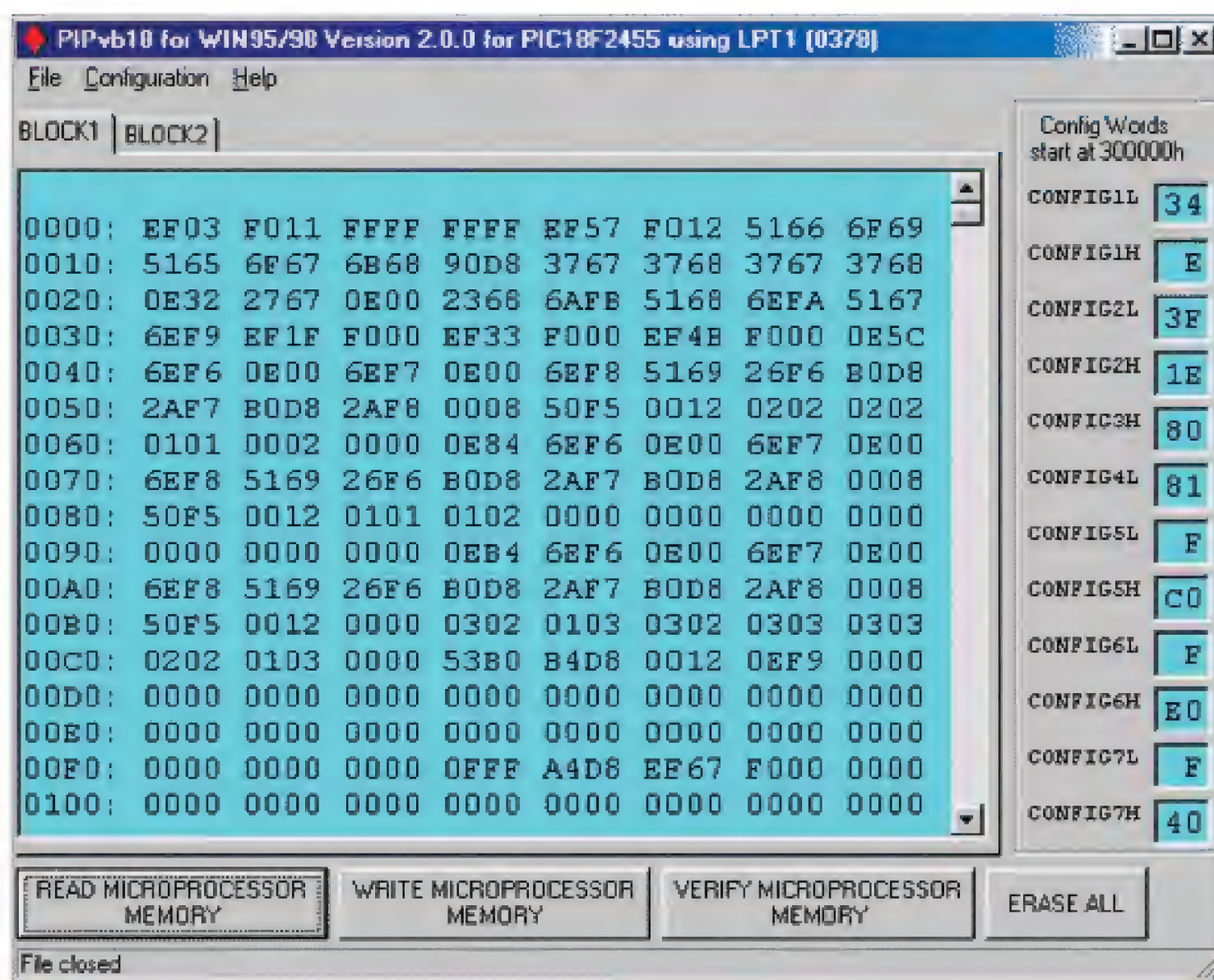


Figure 8. PIPVb PIC Programming Software.

out a serial line at 31,250 baud. For the USB-MIDI input device, the task is to receive the MIDI command over a serial line at 31,250 baud, prepare the MIDI event packet, and transmit it to the PC via USB.

The USB class definitions are a way to define the MIDI device as shown in Figure 6. The device is simple and will

consist of two MIDI endpoints — an IN and an OUT. The OUT endpoint is connected to the embedded MIDI IN jack which is defined as Jack #1 in the USB descriptors in umidi.c. Jack #1 is connected to Jack #4 which is the external MIDI OUT jack. Jack #4 and its connection to Jack #1 is also defined in the USB descriptors. Likewise, the input MIDI flow is defined in a similar manner. The USB device class definition for MIDI devices allows for much more complicated MIDI devices with more jacks and elements like internal synthesizers. Figure 7 shows how the MIDI-nator can be hooked up to a music synthesizer MIDI keyboard and a notebook computer.

MIDI Driver

In order to develop a piece of hardware for the Microsoft® Windows® XP operating system, it is necessary to take a step into the deep water with the Windows driver model. The Windows driver model allows developers to write device drivers that are source-code compatible across all Microsoft Windows operating systems (Reference 4).

By taking care to follow the standard USB device class definition for MIDI devices when writing the firmware for the device, I can use the standard Microsoft USB audio device drivers and avoid having to write my own custom USB MIDI driver. The following standard device drivers will be loaded: *USBAUDIO.SYS*, *KS.SYS*, *PORTCLS.SYS*, *KSPROXY.SYS*, *KSUSER.SYS*, *WDMAUD.SYS*, and *DRMK.SYS*. Using these standard drivers will save me weeks of work, hundreds of pages of reading, and many headaches. Alas, the USB MIDI drivers are only available on Microsoft Windows XP and later operating systems.

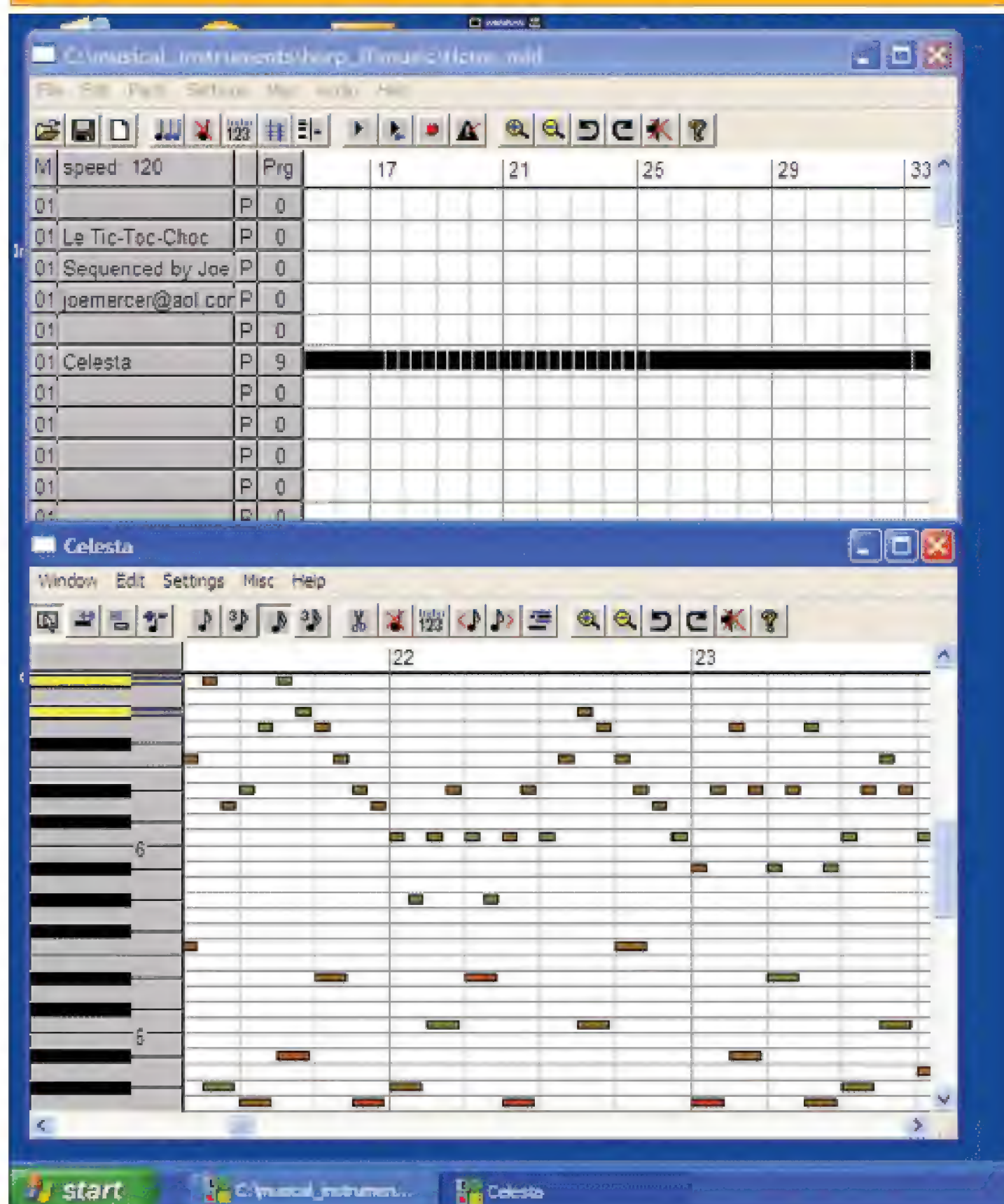
Writing the USB/MIDI Software

The complexity of the USB and MIDI data processing indicated that the device firmware would be fairly long. I decided to write the program in C rather than assembly language and chose the BOOSTC compiler from SOURCEBOOST because of its low price and helpful support (Source 3). BOOSTC has an easy-to-use Windows user interface and the ability to single step through the program. The complete BOOSTC source code for this project is available at Source 4.

For the USB to MIDI interface to work with Windows, there must be a Windows driver that conforms to the specifications of the USB Device Class Definition for MIDI Devices. As I mentioned, Microsoft has written such a driver and it is included as part of the Windows XP operating system. The device's firmware must accept the driver's commands and supply the data in the format the driver needs.

Since the Windows XP USB MIDI driver conforms to the USB Device Class Definition for MIDI Devices, that document can be used for guidance in writing the

Figure 9. Jazz Sequencer Playing MIDI file.



firmware for the PIC18F2455. Where to start when writing the firmware? The first thing that happens when a USB device is plugged in is enumeration. In enumeration, the host first puts the device into RESET mode and LED 0 will light. Then the host asks the device for a number of descriptors that help define the device to the host. Reference 3 defines the format and the content of the descriptors. The C program defines the descriptors in the DeviceDescriptor[] and Config-Descriptor[] arrays. Comments in the program provide an explanation of the contents of the descriptors. If the descriptors are processed successfully, then the device will be in configured mode and LED 2 will light. The MIDI-nator will show up in the system device manager as "USB AUDIO DEVICE."

There is a jumper on the board that is sensed by the software. The software is designed to output additional debug information if the jumper is removed. This will be discussed more in the testing part of this article.

When MIDI data is received from the host via the EP1OUT USB endpoint, it is decoded into serial MIDI data and loaded into a 128 byte circular output buffer for serial transmission. It is transmitted as quickly as possible using interrupts. When MIDI data is available from an external MIDI device via the RX pin on the PIC18F2455, an interrupt occurs and the MIDI data is loaded into a 128 byte

circular input buffer. The MIDI data is processed and assembled into four byte USB MIDI packets. The packets are then read by the host via the EP1IN USB endpoint.

BOOSTC or another C compiler is used to compile and link the C source into the umidi.hex file. The next step in the process is to download the hex file to the PIC18F2455 chip. For this, you will need PIC programmer hardware and PIC programmer software for the PC or you can order the preprogrammed chip from Source 2. There are plans for lots of PIC programmers on the Internet (Source 7) and free PIC programmer software (Source 8). Personally, I use the TAIT programmer hardware that uses the PC's parallel port and the PIPVb programming software shown in Figure 8. Just make sure the programming software is tested on the operating system you are using and works for the PIC18F2455 since the programming algorithm was changed by Microchip for this PIC (Reference 6).

Testing the Hardware With the MIDI Software

Before you plug the device into your computer's USB port, you should check its operation by applying +5 volts and ground to J5. The first thing that should happen is that the LEDs will flash sequentially. This means that the

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(RPS) BS-8-BLK

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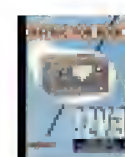
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device is powered and programmed. The device should draw less than 55 mA with the optional RS-232 feature. If it does not, stop and check the circuit. Do not plug the device into your USB port until you are sure your wiring is correct or you may damage your USB port. Some — but not all USB ports — have overload protection.

The next thing to do is to plug the device into your USB port and check that the device is properly enumerated. This can be done using the USBVIEW program. Figure 1 shows the output of the USBView program with the hardware and software of this article connected. USBVIEW shows that the device has one configuration and

has a maximum control packet size of 64 bytes. It operates at full speed and has two open pipes. The first pipe uses bulk data transfers and is for host-to-device data transfers (01) and has a maximum packet size of 64 bytes. The second pipe uses bulk data transfers and is for device-to-host data transfers (81) and has a maximum packet size of 64 bytes.

When I first plugged the device in with the program, it did not work. This meant I needed some way to debug the program. There is a jumper on the board that will switch the board from sending and receiving data at the MIDI baud rate (31,250) to a standard PC serial port baud rate (115,200). With the jumper in this position, additional debug information can be viewed by connecting the device to a PC with a serial port and using the HYPERTERM terminal program. Table 4 shows the commented output of a good enumeration and MIDI data transfer. Please note that in this mode the MIDI connections do not work, but can be simulated by sending MIDI commands from the HYPERTERM terminal program.

The USB Implementer's Forum provides a free program called USB Command Verifier (USBCV) at Source 9. USBCV evaluates high, full, and low-speed USB devices for conformance to the USB Device Framework. It runs a number of tests — such as causing the device to enumerate 150 times — which must be passed. I am happy to report that this device and software passed all the USB Command Verifier tests.

The final step in the testing of the device is to test the transfer of MIDI data into and out of the PC using the USB port. For this, a music sequencer program is needed. There are many sequencer programs on the market, such as CAKEWALK (Source 10) and

USB MIDI Debug Message	Comments
USB MIDI Interface V2.3	Announcement that program has started.
Full speed USB	Running at full USB speed.
USB Init	USB is initialized.
D>H	Device to host transfer.
GD	Get descriptor.
device	Descriptor type = device.
12 01 12	First byte, last byte, and number of bytes transferred in hex.
H>D	Host to device.
SA	Set device address.
01	Device address is 1.
D>H . . .	Repeats device request.
D>H	Device to host.
GD	Get descriptor.
config	Descriptor type = config.
09 32 09	Sends first nine bytes of config descriptor.
D>H	Device to host.
GD	Get descriptor.
config	Descriptor type = config.
09 00 40	Send 64 bytes of config.
05 03 13	Sends last 19 bytes of config.
D>H	Device to host.
GD	Get descriptor.
string	Descriptor type = string.
04 04 04	Specifies string language.
D>H	Device to host.
GD	Get descriptor.
string	Descriptor type = string.
2a 00 2a	Sends product string.
D>H . . .	Repeats previous two strings.
D>H . . .	Repeats device and config descriptors.
H>D	Host to device.
SC	Set configuration.
01 C	Configuration is set to 1.
D>H . . .	Repeats two string requests.
EPlout	Some MIDI initialization.
0b b0 7a 00	Messages are received.
. . .	
09 90 3c 64	MIDI note on for middle C.
EPlout	
09 90 3c 00	MIDI note off for middle C. A note off is a note on with velocity of 0.

Table 4. Debug Output from Good Run.

many others available for free on the Internet, such as JAZZ (Source 11). The MIDI sequencer program can be used to play, record, and edit MIDI music files. To record a MIDI file, you need a music synthesizer MIDI keyboard for input.

Figure 9 shows the free JAZZ program playing a MIDI file. To record music in JAZZ, you just highlight the measures you want to record and hit the record button, then just play what you want to record on the music synthesizer MIDI keyboard. Don't worry if you make mistakes because you can always go back and edit the recorded MIDI file to correct any errors. One note of caution, however: Do not select the USB AUDIO DEVICE as both the input and the output in JAZZ when recording unless the output is muted. Doing so can set up an internal MIDI feedback loop which can cause havoc.

Conclusion

An interesting project which allows new portable computers using the XP operating system to drive MIDI musical instruments has been constructed for about \$21.00. This project provides an introduction to the USB and MIDI protocols, to one of the new USB flash microprocessors from Microchip, and to the new low priced BOOSTC compiler from SOURCEBOOST. With this device, USB Notebook computers are now MIDI enabled. **NV**

Sources

- Source 1 — USBVIEW available at www.ftdichip.com/Resources/Utilities.htm
- Source 2 — RLANG homepage at www2.netdoor.com/~rlang
- Source 3 — BOOSTC Compiler at www.picant.com/c2c/c.html
- Source 4 — Nuts & Volts FTP website at www.nutsvolts.com/ftp/index.htm
- Source 5 — Jameco at www.jameco.com
- Source 6 — Microchip at www.microchip.com
- Source 7 — PIC Programmer Schematic at www2.netdoor.com/~rlang/vacutron/pic_prog_schematic.jpg
- Source 8 — PIC Programmer Software at www.ic-prog.com/index1.htm
- Source 9 — USBCV Computer Program at www.usb.org/developers/tools/
- Source 10 — Cakewalk website at www.cakewalk.com
- Source 11 — Jazz free download site at www.jazzware.com/cgi-bin/Zope.cgi/jazzware/

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This project adds two DB-15 connectors in the handles of a game pad. The connectors provide access to all the game pad I/O except for two tri-state hat signals. Your custom hardware can access the PC through the connectors, or override any or all of the four axes of the built-in analog controls with external potentiometers. The pinout of each connector is close enough to the standard game port that with only a minor modification, your old joysticks can be brought back to life with the speed and precision of USB (see "An Introduction to USB" *Nuts & Volts*, May 2004).

The completed project is shown in Figure 1. The number of signals provided by this modification is shown in the table below. The game pad remains fully functional except for the vibration feedback. The signals that drove the two motors become the two output signals.

Inputs

12 digital
4 analog

Outputs

1 analog or digital (depends on revision)
1 digital

Figure 1. Completed Interface.



General Considerations

Most of the information in this article pertains to the Gamers Factory model Model G60310A. The main obstacle with modifying other game pads may be the lack of space; many are physically smaller. The method used to estimate impedances was by measuring the time interval for a capacitor to charge or discharge by two-thirds ($r \cdot c = t$.) This method can be used with other game pads.

Even within the one model covered, I discovered some minor variations. There are at least two versions of the main board (see Figure 10): version 2268-01-11 (illustrated) and version 2268-01-12 with a slightly different track layout. Since the modification to the main board involves finding I/O points, this issue is easy to resolve. You can trace I/O points visually, with an ohmmeter, or by shunting points through a 1K resistor to ground while running the software test described later. Revision 2268-01-12 also adds analog control to the left motor signal and changes B9 and B10 buttons to active high.

If you plan to interface to external electronics that have their own separate power supply, the safety features described later are highly recommended. If you wish to physically incorporate the Interface within an electronics project, you only need the main board with the I/O connection points added. However, you should always perform the work bench test before connecting any of these alternatives to your PC.

Circuit Design

Connecting two buttons in parallel creates an OR

Abbreviations

JL	Jack Left, (DB-15 Female Connector)
JR	Jack Right, (DB-15 Female Connector)
XL	X-axis Analog Input, Left
YL	Y-axis Analog Input, Left
XRa	X-axis Analog Input, Right
YRa	Y-axis Analog Input, Right
XRb	Duplicated XR on JL (allows 4 axis control on JL)
YRb	Duplicated YR on JL (allows 4 axis control on JL)
Bx	Button x
OL	Output Left
OR	Output Right
TS-L	Thumb Stick Button Left
TS-R	Thumb Stick Button Right
CLx	Cable Left x
CRx	Cable Right x

function, which is exactly what we want to allow functioning of both the internal buttons and external connected signals. The analog inputs require more analysis but the solution turns out to be quite simple.

Adding isolation resistors between the internal potentiometers and buffers eliminates the need for any switches or jumpers to select the analog source. The internal game pad 10K potentiometers drive high impedance buffers. The 100K series resistors have the following effect: when no external controls are connected, the internal pots function normally; when an external pot is connected directly to a game pad buffer, it reduces the gain of the internal pot and takes control. A complete analysis is provided in the link "ControlInteraction.xls" on the *Nuts & Volts* website (www.nutsvolts.com). If an analog signal is the source, it is essentially unaffected by the internal pot.

The final version added a few optional parts for safety; fuses and protection diodes across the four analog inputs. Figure 2 shows the components added to the control board in bold. Figure 3 shows the I/O connections from both boards.

Construction

Test the game pad before starting any modification. Once the device is opened, the warranty is void. The device can be tested using a Windows built-in test as described later.

The tools I found particularly useful are shown in Figure 4. The Dremel cutting wheel provides a convenient way to cut the plastic slots for the two connectors and for cutting track. Cutouts



Figure 4. Recommended Tools.

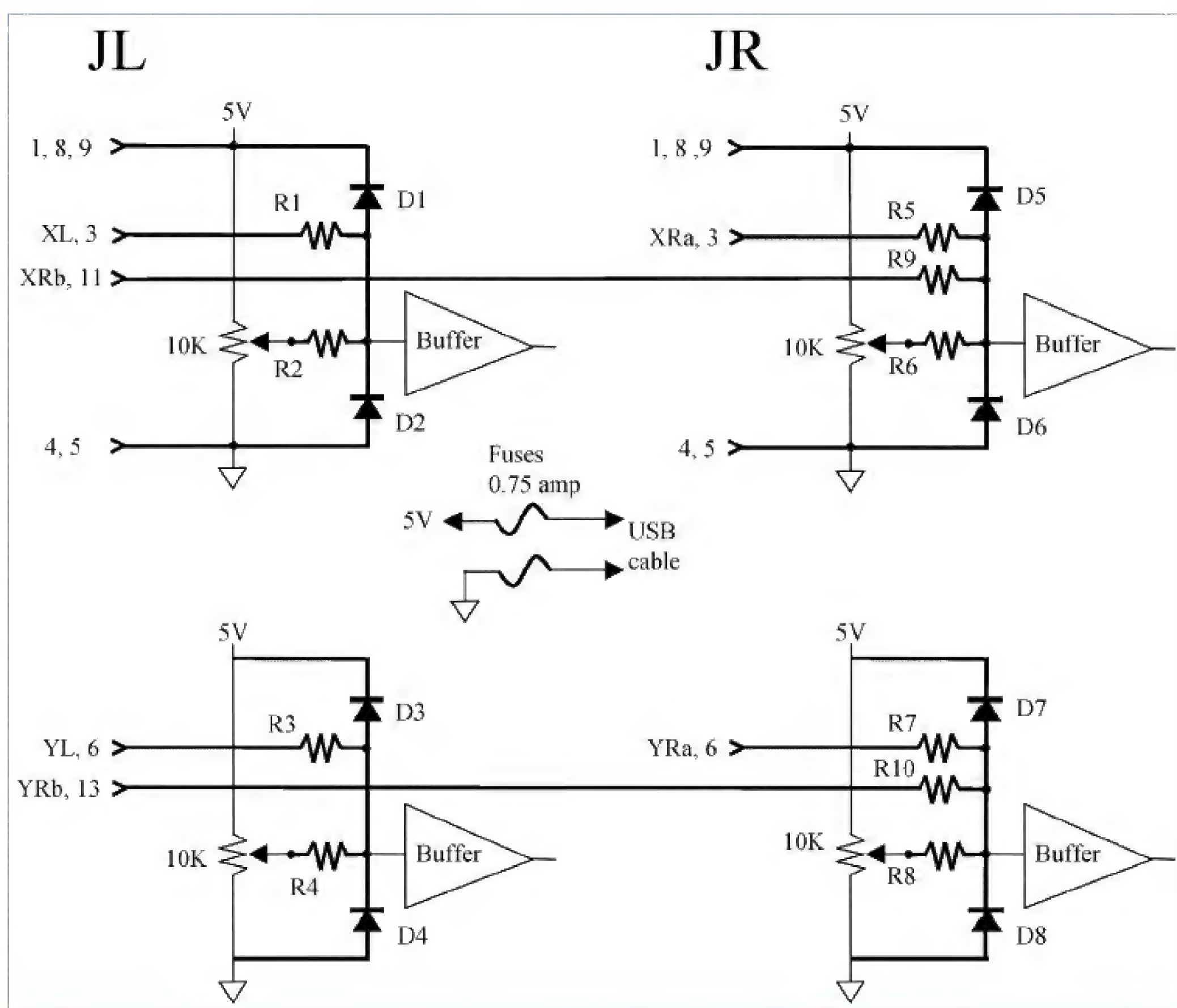


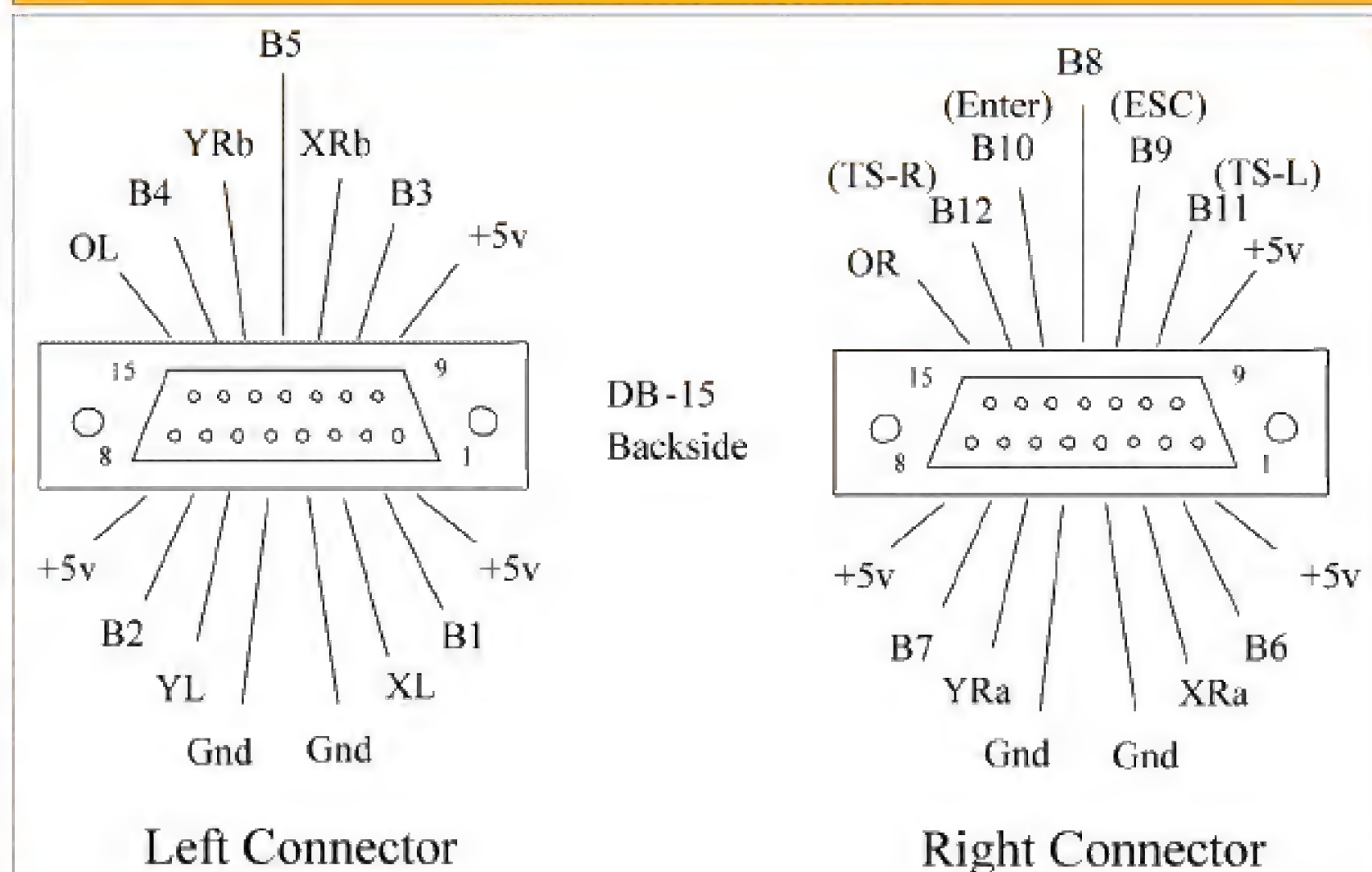
Figure 2. Control Board Schematic.

can be trimmed using the grinding wheels. The bit size for wiring should be about 0.035 inches as discussed in "PCB Layout Tips," *Nuts & Volts* November 2004.

Disassembly

Disassemble the gamepad by removing the five

Figure 3. I/O Connections.



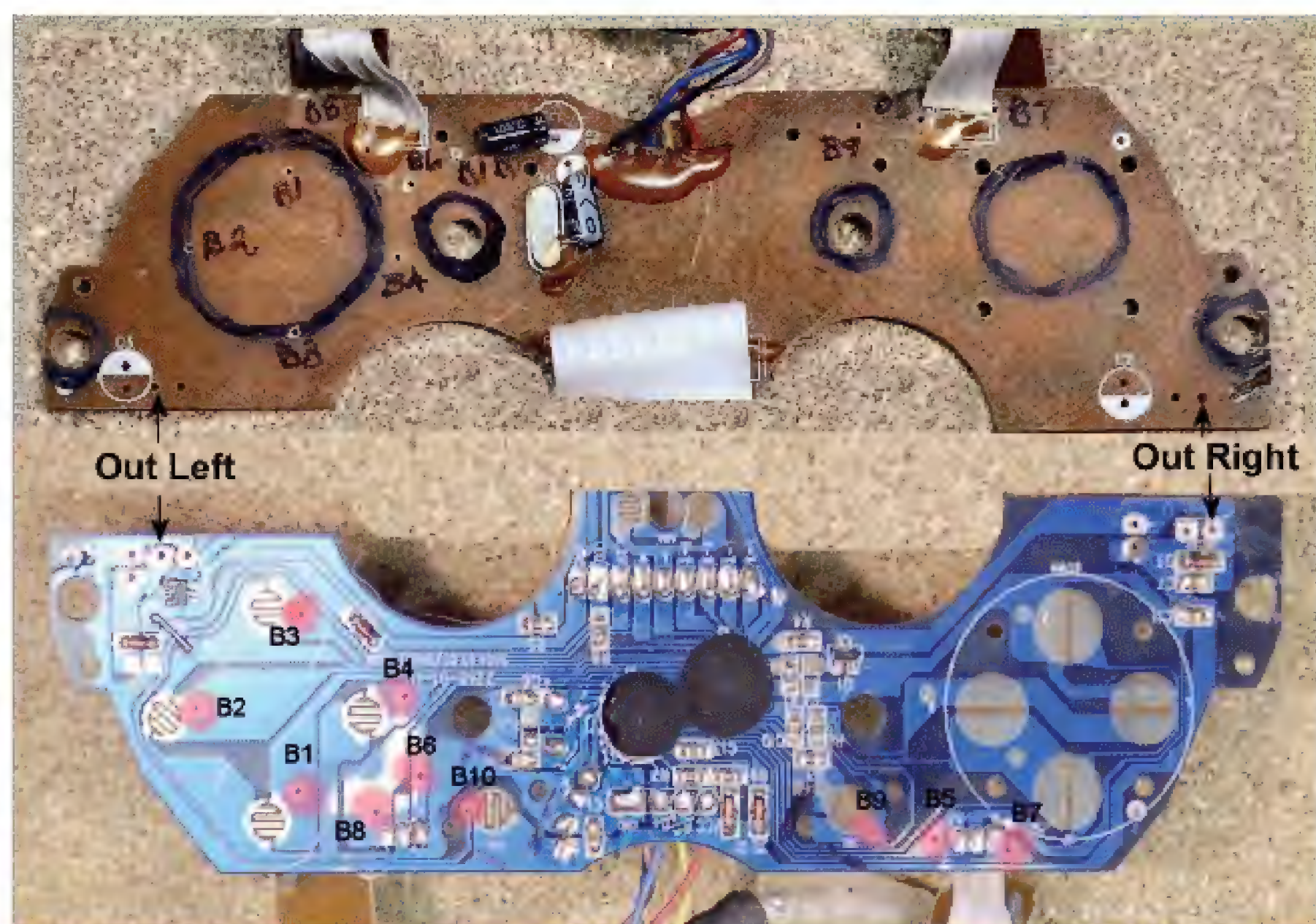


Figure 5. Main Board Modifications.

screws located on the backside. The electronics are contained in two boards wired together by a ribbon cable; the main IC board and control board. It is worthwhile to mark the location of the many mechanical obstructions to both circuit boards. After removing the cover, smear some lipstick on all the posts. Then place the cover back to leave an impression on the board.

The two motors are removed, then the two boards which are held in place by two screws each. After remov-

ing both boards from the case, you can either temporarily tie the USB cable to the main board or unsolder it to prevent damage. You can also add and leave two wires connected for workbench powering of the board until the modification is finished. You can connect these wires to the USB cable power points on the main board or to the fuse holders, if used.

Main Board Modifications

Buttons B1-B4, B9, and B10 have test pads which can be drilled to provide I/O connection points (see Figure 5). For buttons B5-B7, holes are drilled in convenient track areas. Capacitors C3 and C7 are removed and replaced by 1K resistors to provide a faster response time for the motor output signals. Fine emery cloth is used to remove the blue

protective coating.

Control Board Modifications

Five track cuts are made to the control board as shown in the shaded areas of Figure 6. The free pad created in the middle of the board is later used as a tie point for the YL signal. A combination of six holes and slots is created in the edges of the board to fasten the tie points of the analog input resistor pairs R1-R3, R5-R7, and R9-R10. Figure 7 shows the board with added components in place. Jumpers on the track side of the board connect YRb, XRb, and YRa to their input resistors as shown in Figure 10. If you include the safety diodes, it is worthwhile to run a work bench test periodically to make sure a diode isn't in backwards.

Figure 6. Control Track Modifications.

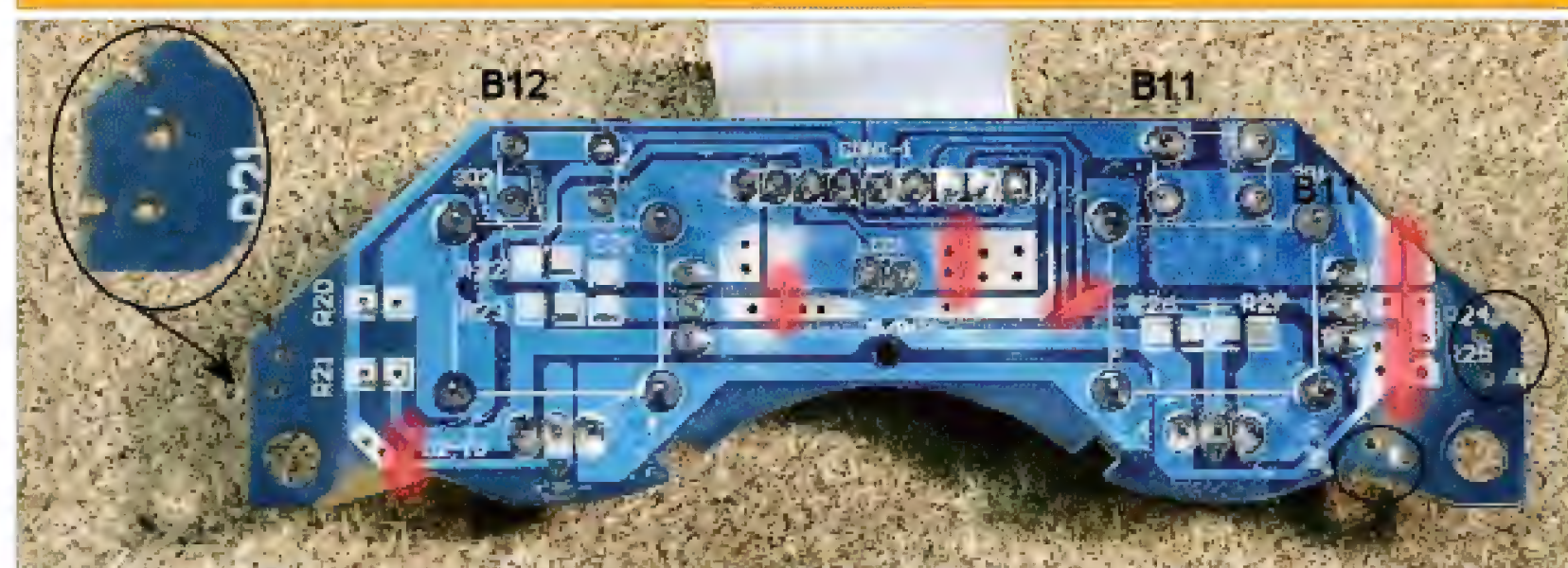
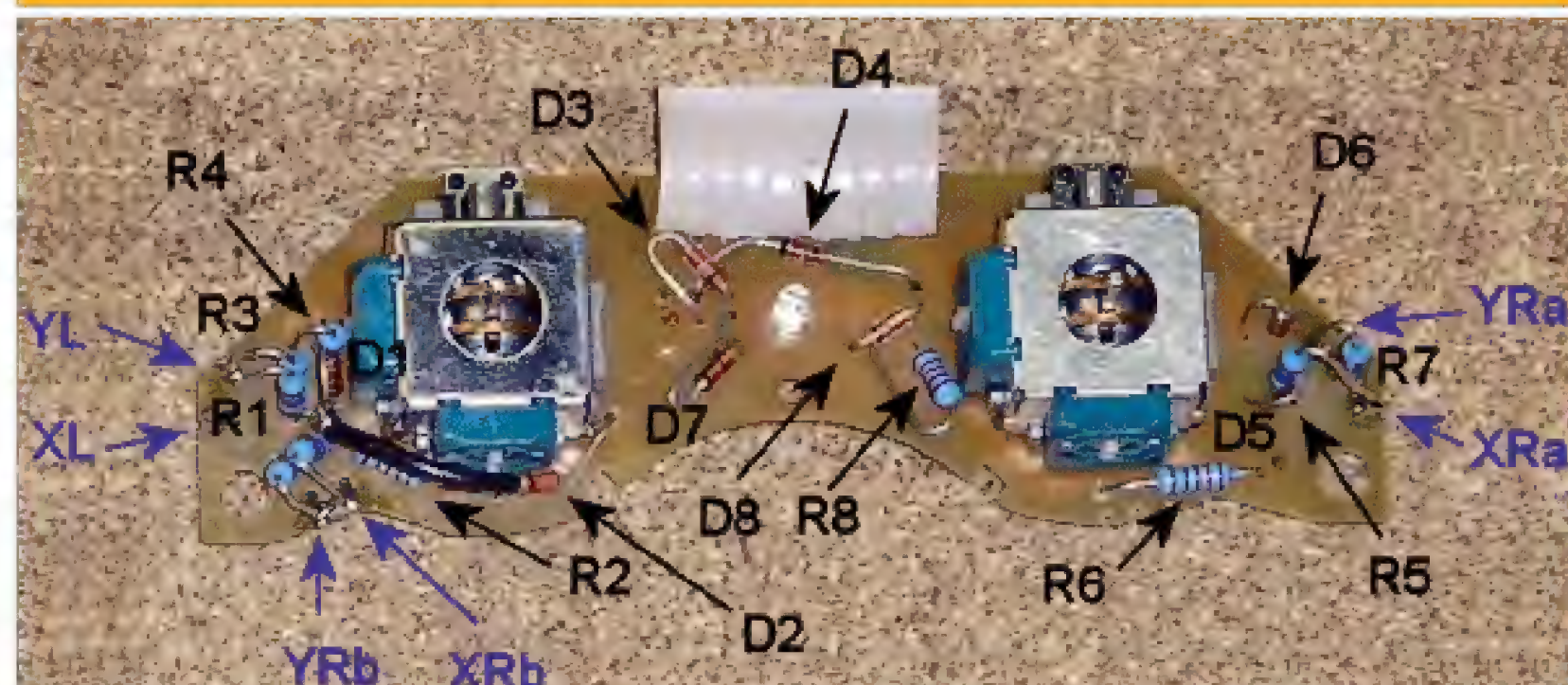


Figure 7. Wired Control Board.



Case Modifications

The partitions that keep the motors in place are removed from both case covers. They are thin and can be cut and snapped out. Trim with grinding wheels. Figure 8 shows the location of the DB-15 connector in the top half of the case. The post on the left handle is at the correct location for the upper hole, but on the right handle the position must be measured from the lower post. The connectors were fastened with 4-40 hardware. One 6-32 nut in each mount location was used as a spacer to slightly recess the connectors.

Figure 9 shows the approximate location of the fuse holders. Try to position the fuse in the center of the concave shelf. To avoid cracking the

case, start with a 1/8-inch bit and gradually increase the hole size. The final 1/2-inch bit should be turned by hand. After fastening the fuse holders, bend the top terminal down to increase clearance when case is assembled. If necessary, clearance can be increased further by adding a washer under the top of the fuse holder.

The cylinder on the right hand of the back cover is notched as required to avoid crimping wires when the unit is assembled.

Cabling

Four cables were used to make interconnections with the DB-15 connectors, as shown in Figure 10. The coding used is shown in Table 1. Before assembling the case, CL1 and CR1 should be moved over the top of the main board and around the inside of the side posts. The cables can be held in place with silicon compound.

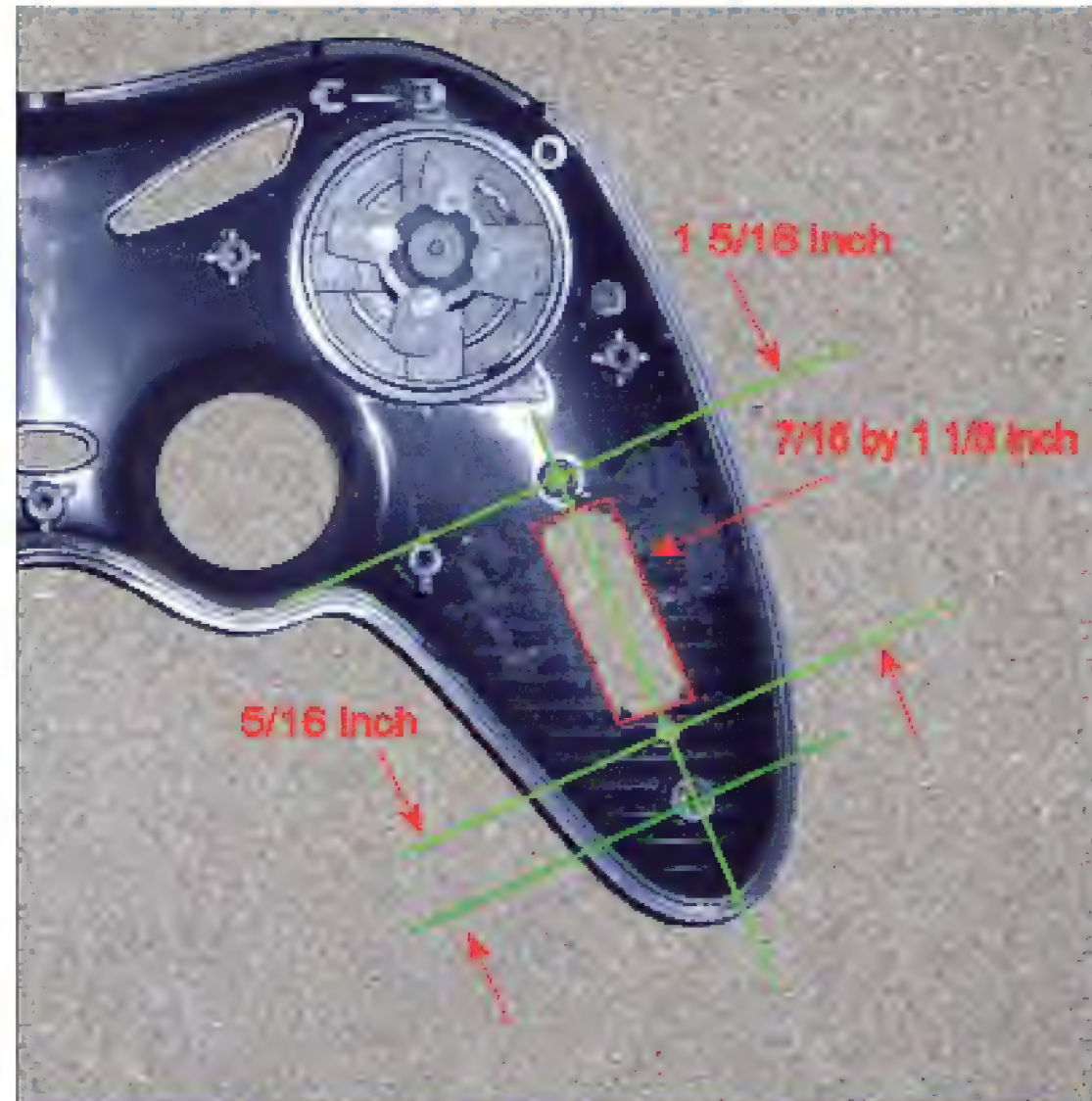


Figure 8. Connector Placement.

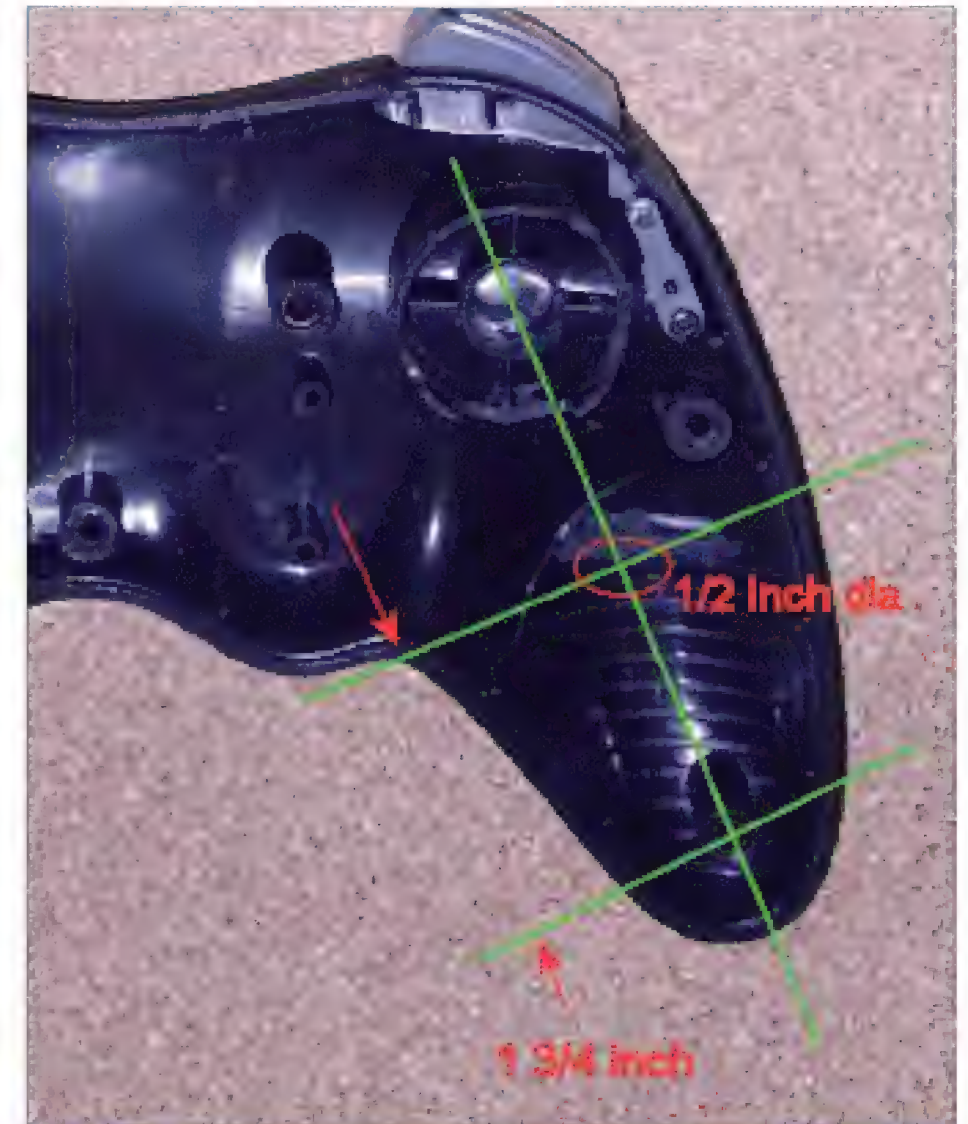


Figure 9. Fuse Placement.

Assembly

Keeping all the cables and levers in place while the case is assembled can be tricky. By using wires to secure levers R1, R2, L1, L2 and the USB cable as shown in Figure 11, the

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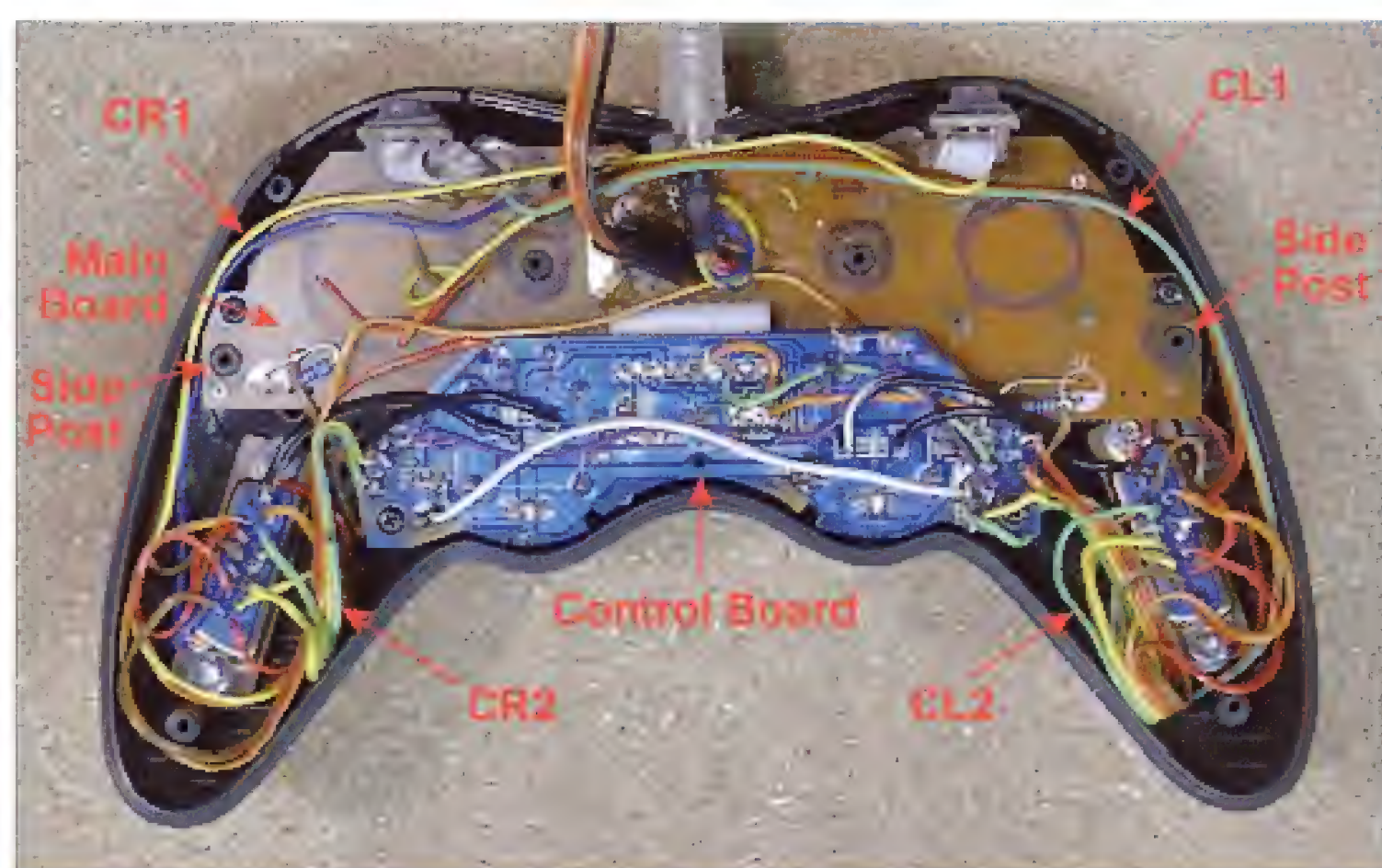


Figure 10. Interface with Cabling Installed.

task is made much easier. You then only have to make sure that the cable to the fuses is not caught under a post.

Workbench Testing

This test makes sure you haven't made any mistakes that could damage your computer. It also aids in troubleshooting. Connect the interface to a 5V power supply

Color	CL1	CL2	CR1	CR2
Brown	B1	OL	B8	OR
Red	B2	YL	B10	YRa
Orange	B3	XL	B9	XRa
Yellow	B4	YRb	B6	B11
Green	B5	XRb	B7	B12

Table 1. Cable Coding

through a 0.75 amp fast-acting fuse. With power applied and thumb sticks at neutral, check that the pot outputs and buffer inputs are about one-half the supply voltage. Next, check that the voltage at these points varies as you move the thumb sticks. Then use the mode button to place the game pad in analog mode. The LED should light. If all this works, then you can proceed to PC Testing.

PC Testing

Windows 2000 and Windows XP include a built-in test program for USB controllers. These will work fine even without the Gamers Factory software installed. To test the thumb sticks, place the Game Pad in analog mode by pressing "Mode."

Parts List

Gamers Factory USB Game Pad	Best Buy Model: G60310A
2 — DB-15 female connectors	MCM Electronics, part no. 83-230
2 — Fuse 0.75 amp	MCM Electronics, part no. 28-285, RadioShack 270-1048
2 — Fuse holder	MCM Electronics, part no. 28-0175, RadioShack 270-362
4 — 100K resistors (R2, R4, R6, R8)	RadioShack, Digi-Key, MCM Electronics
8 — 1K resistors (all others)	RadioShack, Digi-Key, MCM Electronics
Ribbon or jacketed cable	RadioShack, Digi-Key, MCM Electronics
Misc hardware	Home Depot, Lowes, RadioShack

For Windows XP:

Click on Start, Control Panel, Printers and Other Hardware, Game Controllers, Properties.

For Windows 2000:

Click on Start, Settings, Control Panel, Gaming Options, Properties.

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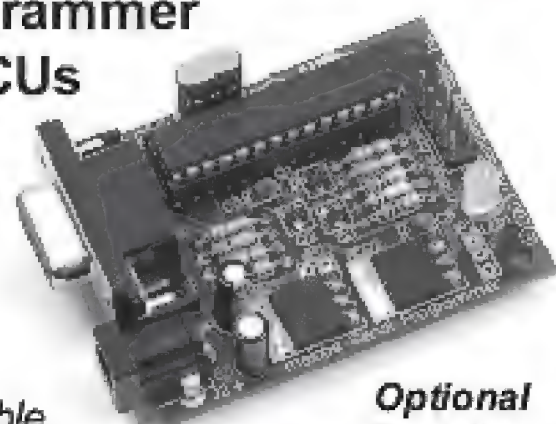
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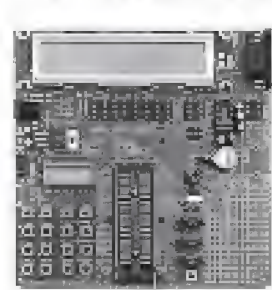
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Figure 11. Assembly Aids.

Using the Interface With Joysticks

The old style joysticks require a simple modification to be used with the Interface. The potentiometers need to have a ground connection, as well as five volts, as shown in Figure 12. Note that the five-volt connection to the X-axis pot is reversed. Some joysticks have additional analog controls called X2 and Y2. If you modify these potentiometers in the same way, they will be functional. You can connect one joystick with X2 and/or Y2 controls to the left connector, or two joysticks without extra controls.

Using the Interface With Custom Controls

The game pad analog controls can be individually overridden by external potentiometers in the 10K to 100K range. One purpose would be to create a more useful throttle control that doesn't automatically return to neutral when released. Or you could substitute your own foot pedals or a steering wheel for an internal analog control. Similarly, you can add any of the 12 digital controls to a custom controller by wiring your own buttons to the appropriate pins. In addition, a repeater function can easily be added with a 555 timer.

Using the Interface With Custom Electronics

The analog inputs have an impedance of approximately 100K that is easily driven by any IC device. The button inputs have pull-up resistors of about 7K which can be driven by almost any logic gate family. Some applications for custom electronics might be data logging of temperature, power consumption, or speed over long periods of time, or remote control of a PC. Including a final driver stage that uses the gamepad 5V in your project will reduce the chance of accidental damage to a PC.

About the Author

Larry Brooks has a Masters in EE from Loyola College. He has many years of professional experience working as both a hardware design engineer and programmer.

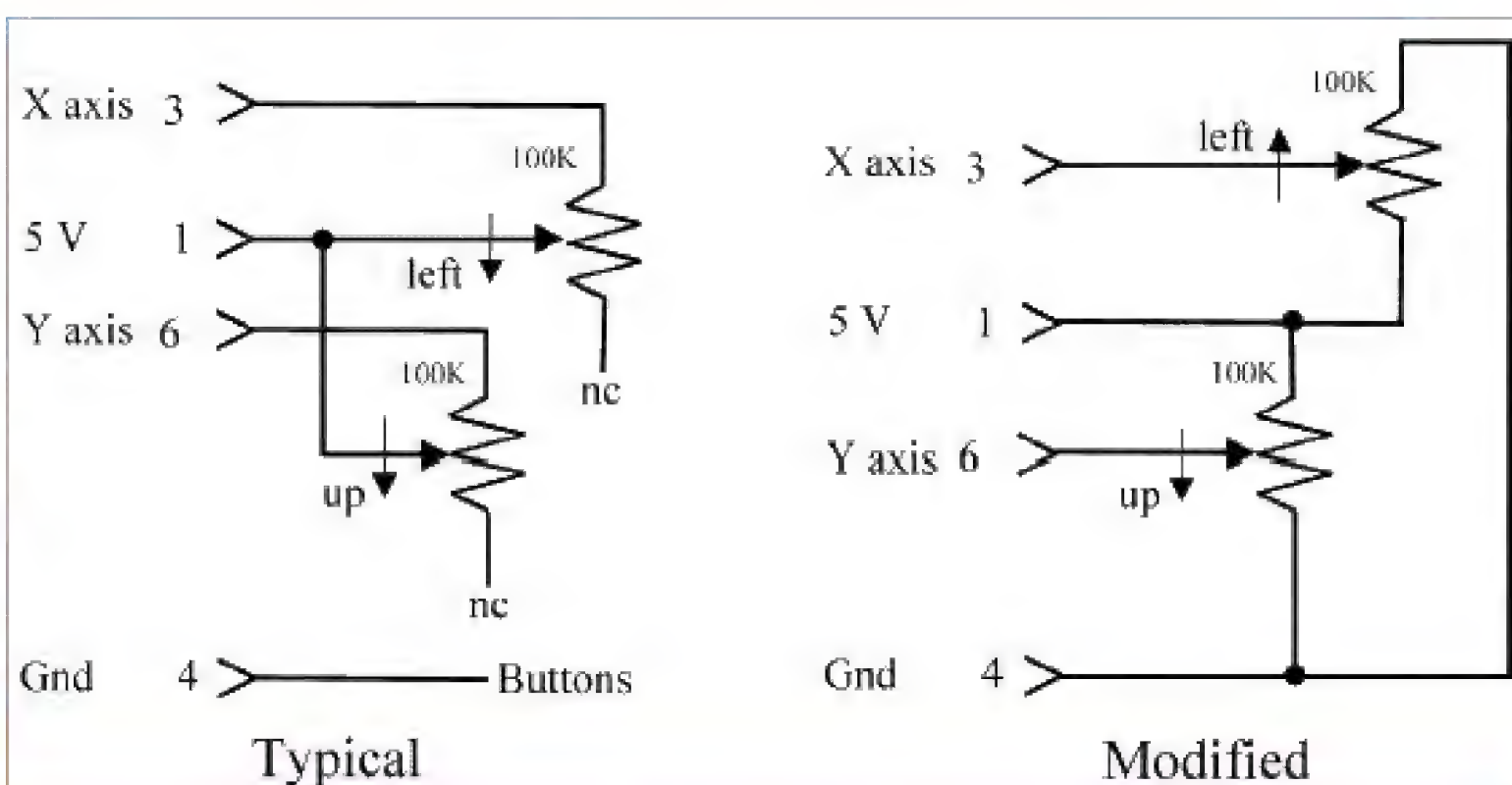
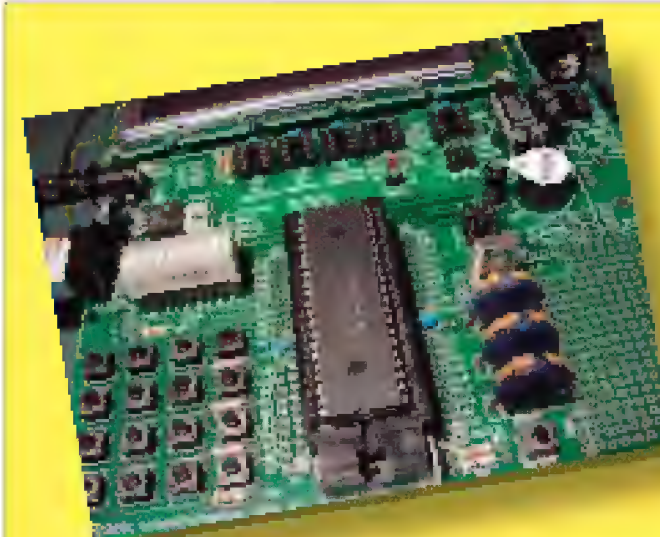


Figure 12. Joystick Modification.

Future Work

An article is planned to show you how to talk to the Interface through your own Windows program using Microsoft's Direct Input API. In that article, a program will be developed that can be used to test the maximum throughput of the digital inputs and maximum slew rate of the analog signals. In the meantime, I hope you come up with some other neat applications for this low-cost interface. And please share them with other *Nuts & Volts* readers. **NV**



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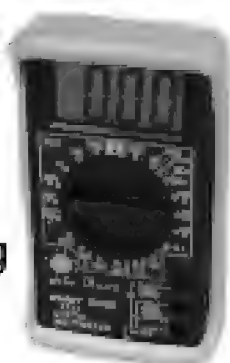
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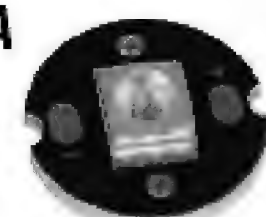
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The Ultimate Utility Meter

Part 2 — Operation

Last month, we assembled and tested our Ultimate Utility Meter (UUM). This month, I will show you how to operate the UUM.

UUM Operation

First, let's go over the keys on the keypad. Some keys have a specific purpose depending on which command is active.

Cursor Keys

The logic analyzer has two cursors. You move Cursor 1 using the keys 1 and 3. Think of Cursor 2 as a reference cursor. It is set by hitting the 2 key. The difference between the cursors is always displayed on the display shown in Figure 3.

Page Keys

The logic analyzer always captures four pages of data. To move between the pages, use the INC Page and DEC Page keys shown in Figure 2. Notice that Cursor 2 always stays where you set it. Cursor 1 moves with the page. This way, you can take measurements between pages.

A small black bar will move indicating the current page you are on, as shown in Figure 4.

Scale Key

The scale key allows you to change the resolution of the next capture. The scale shown in Figure 5 displays the number of microseconds for each pixel.

Note that this is the smallest point of resolution of the current capture. The following scales are supported:

1.7 μ S
3.0 μ S
4.3 μ S
5.7 μ S
7.8 μ S
13.4 μ S
24.5 μ S
48.2 μ S
86.0 μ S
200 μ S

Capture Data Key

This key will start a data capture. If triggers are used, it will wait until the trigger condition has been set. You can hit the key if you wish to exit the capture mode.

Command Keys

The command keys allow you to change other parameters or issue certain commands. The active command/parameter name is displayed as shown in Figure 6.

Once a command is selected, the 7, 8, and 9 keys are used to change the values or execute the command.

Let's take a look at each command or parameter in detail.

Delay

This command (Figure 6) will allow you to insert a

Figure 1. The completed project.



Figure 2. The keypad.

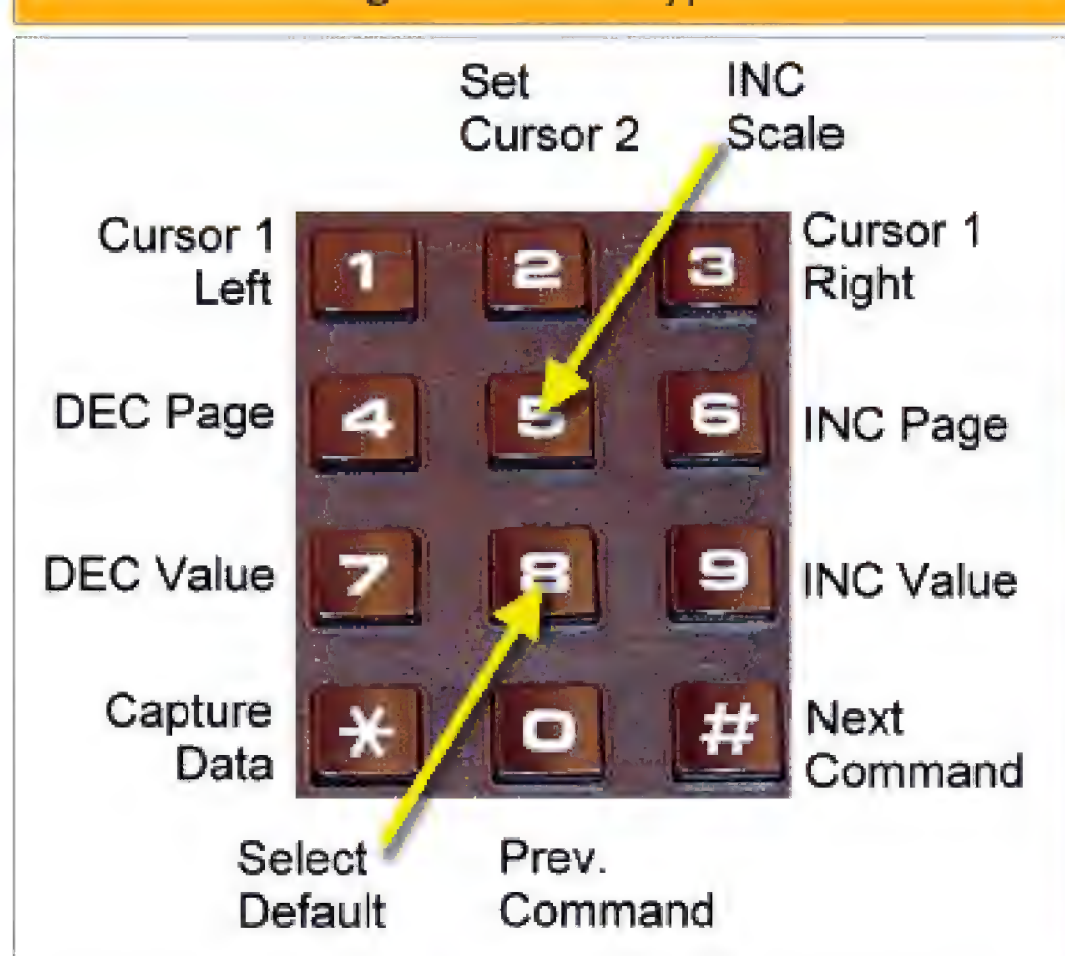


Figure 3

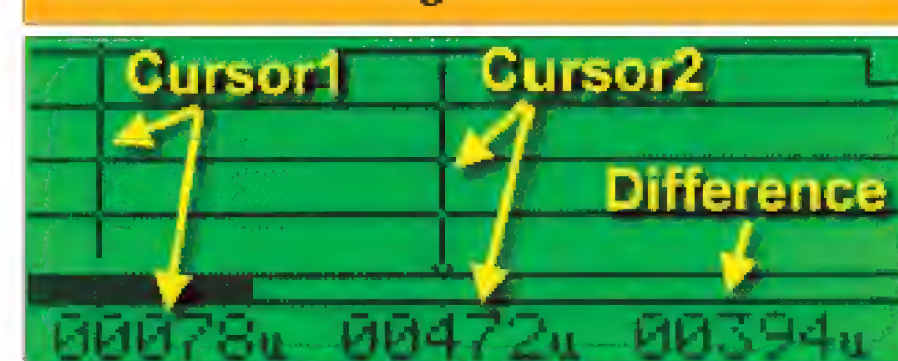
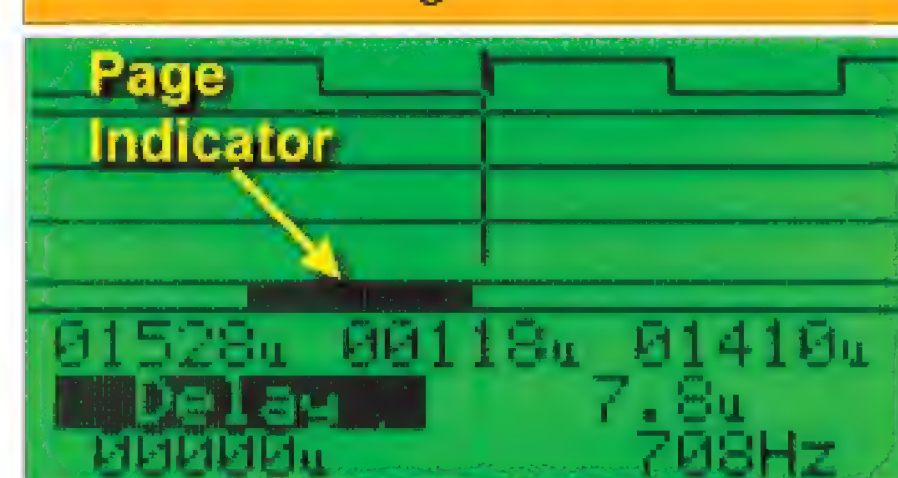


Figure 4



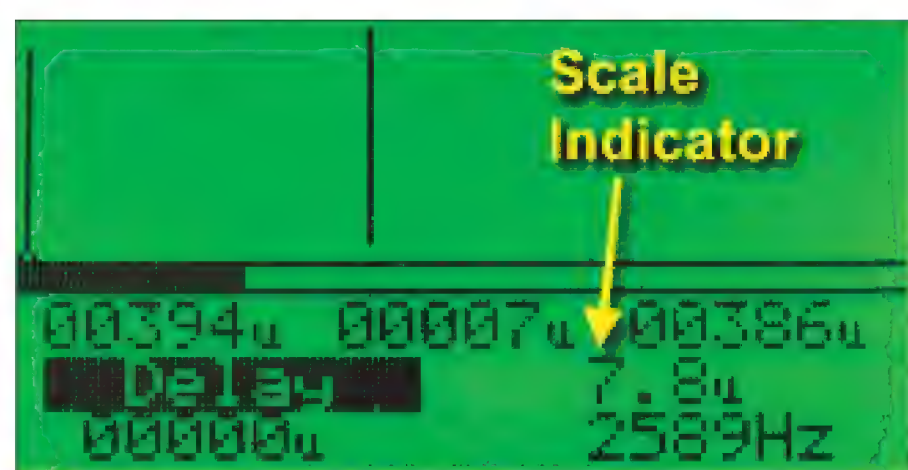


Figure 5



Figure 6



Figure 7



Figure 8

delay before the logic analyzer starts the actual capture. Use the 7 and 9 keys to change the value. The 8 key sets the value to 0.

Pullups

This command (Figure 7) allows you to turn weak pull-up resistors on or off on all the analyzer ports. Use the 8 key to toggle on and off.

Backlight

The backlight command (Figure 8) allows you to set the intensity of the back light. Use the 7 and 9 keys to change the value. Use the 8 key to set it to 200.

Channels

There are three display modes for the logic analyzer. You can display all eight channels as shown in Figure 10 or select channels 0-3 or 4-7 as shown in Figure 9. When

as well.

Edge Trigger

Here you can set one of the channels as an edge trigger. This normally is used to monitor a single repeating signal. It will wait one complete cycle, then trigger on the low-to-high or high-to-low, depending on which is selected.

Using the edge trigger will turn off the word trigger if it has been activated.

Use the 7 and 9 keys to select the channel and the 8 key to toggle the low-to-high or high-to-low transition. If no trigger has been set up, the word none will be displayed as shown in Figure 13.

Word Trigger

This command (Figure 14) will allow you to set a condition on any of the eight channels. You can set each channel to Low, High, or None. If set to None, that

you only need a couple of channels, the 0-3 or 4-7 channel options are much easier to see.

You can change the channels at any time. The current capture data will be redrawn.

Reset

This command will reset both the graphic serial LCD and the controller. The 8 key will do the reset.

Save

This command allows you to save all the current parameters so that they will be loaded the next time you start the UUM.

Use the 8 key to save. Cursor location and scale settings are saved,

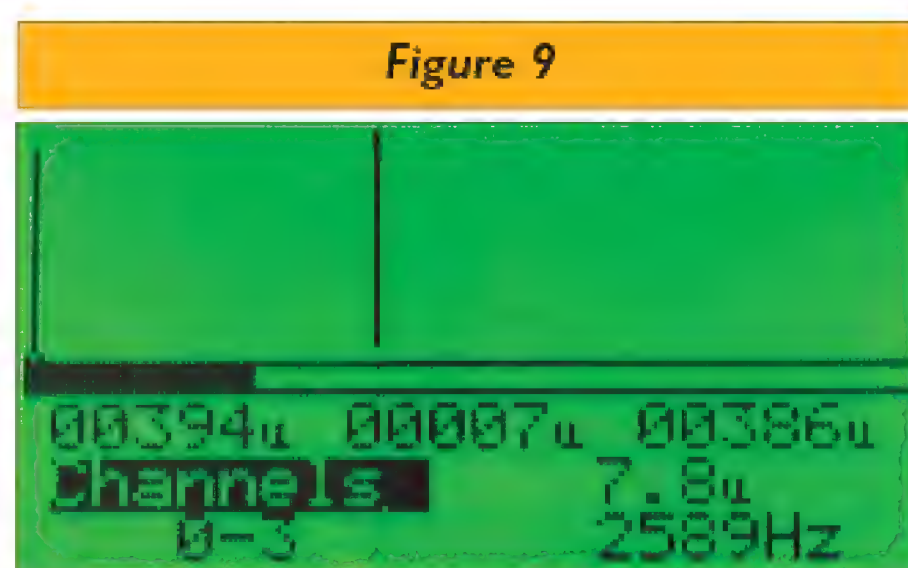


Figure 9

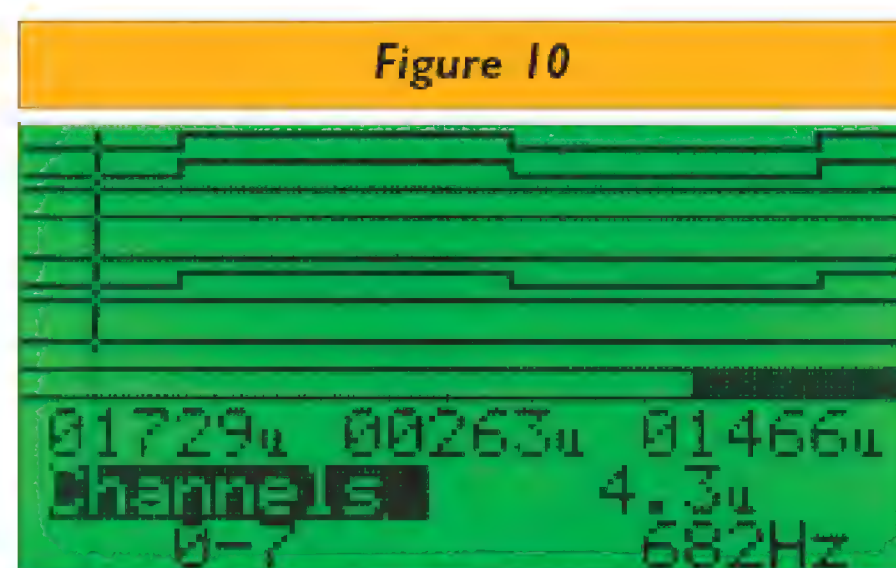


Figure 10

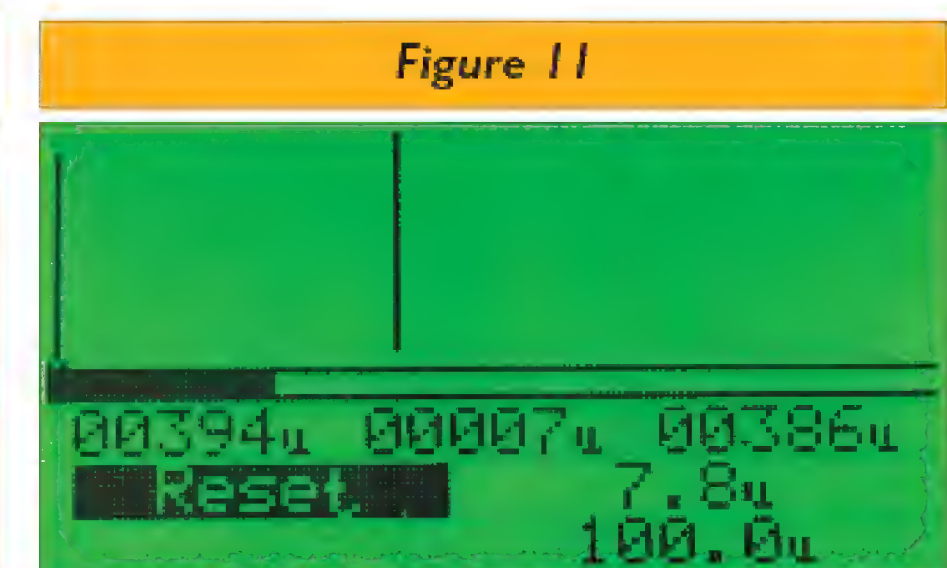


Figure 11

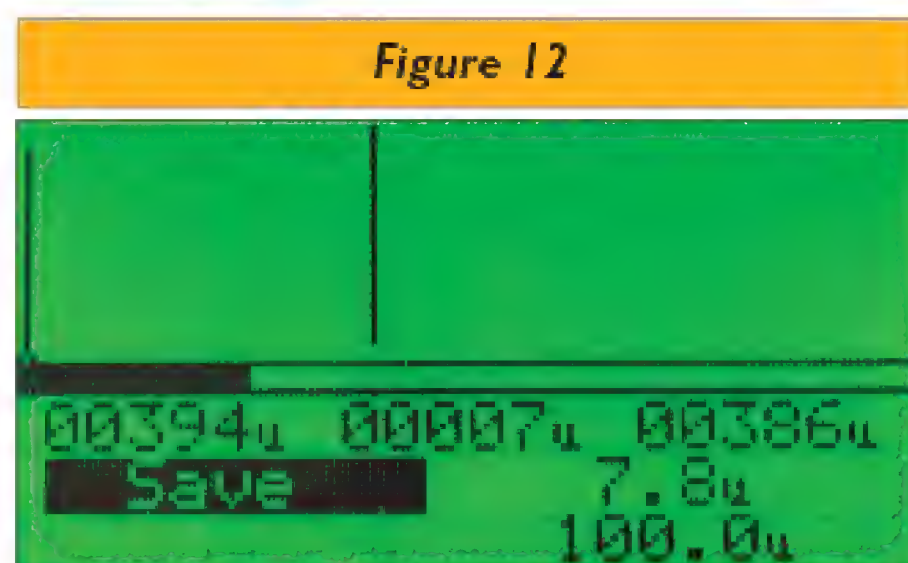


Figure 12

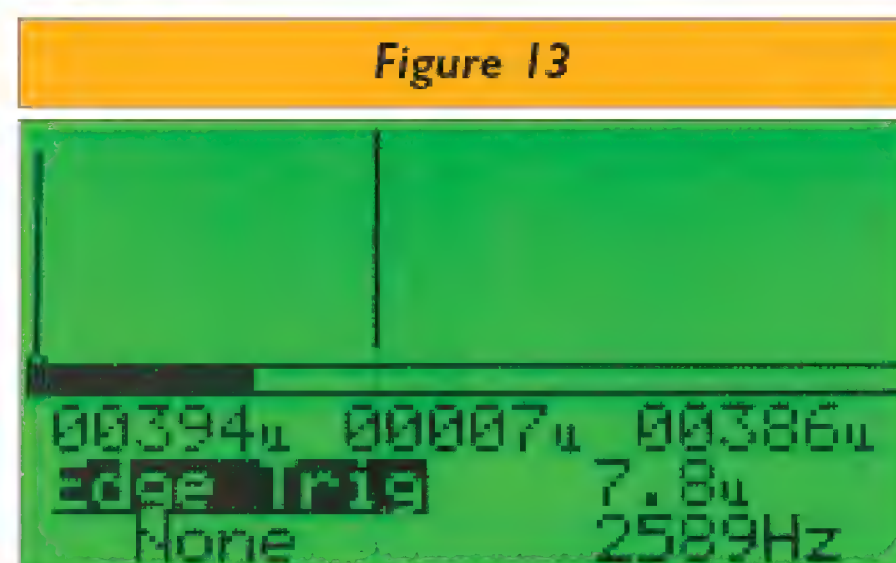


Figure 13

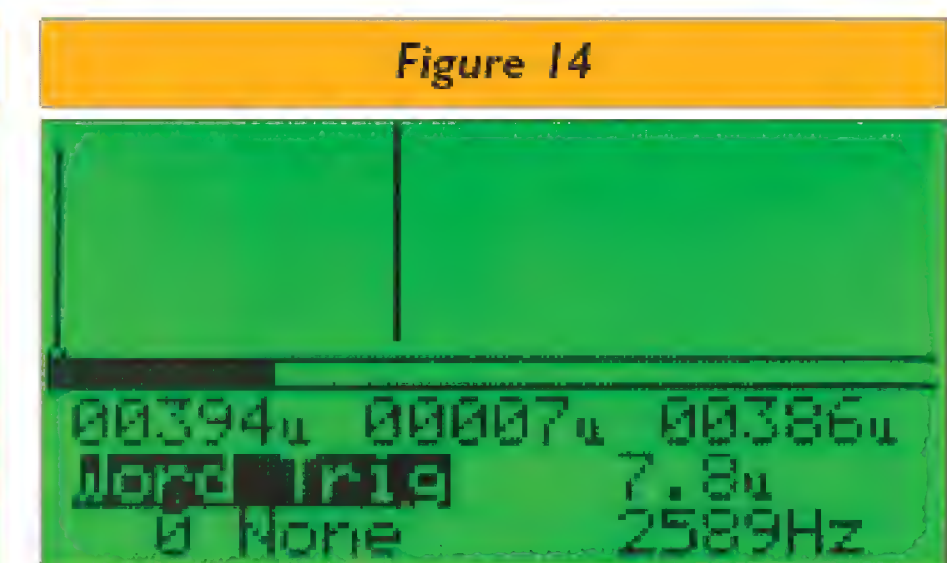


Figure 14

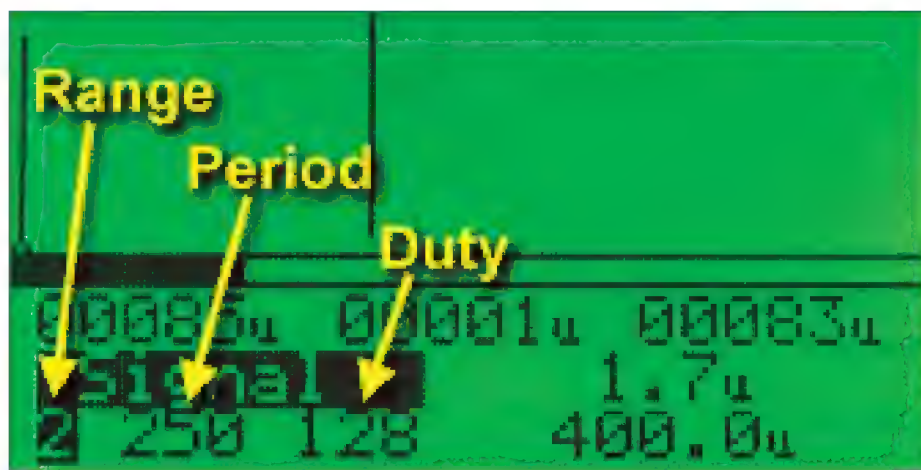


Figure 15



Figure 16



Figure 17

channel will be ignored for the trigger condition.

When you start a capture with the * key, the analyzer will wait until all the channels are in the trigger condition. Once the conditions have been met, the delay — if set — will be activated; then the capture will start.

Change the channels with the 7 and 9 keys, then use the 8 key to toggle between the Low, High, and None conditions. If you don't wish to use any trigger condition, set all channels to None.

Signal

This command (Figure 15) will allow you to change the value of the built-in pulse generator. Use the 8 key to jump between the three parameters, and the 7 and 9 keys to change the values.

Valid Ranges

- Range 0: .1 uS to 25.5 uS in .1 uS increments
- Range 1: .4 uS to 102 uS in .4 uS increments
- Range 2: 1.6 uS to 408 uS in 1.6 uS increments

The output is placed on Port 13. It is marked Signal on the schematic.

Monitor

The monitor (Figure 16) is used as a logic probe to monitor eight ports at one time. Use the 8 key to activate the monitor.

Once activated, the monitor screen will be displayed, as shown in Figure 17.

A dark square indicates a logical 1, and an empty square indicates a logic 0. A small arrow will point to the ports that have changed recently.

To exit the monitor, just hit the * key.

Analyzer Examples

1Wire

Here, I set port 1 on the analyzer to monitor the data channel on a 1Wire device. This captured sequence shows the 1Wire reset and a byte of 170 (\$CC) being sent.

Figure 18 shows two of the captured pages. Notice



Figure 18

that the Word Trigger for Port 1 has been set to low. This means that once started, the analyzer will wait until it sees the port go low.

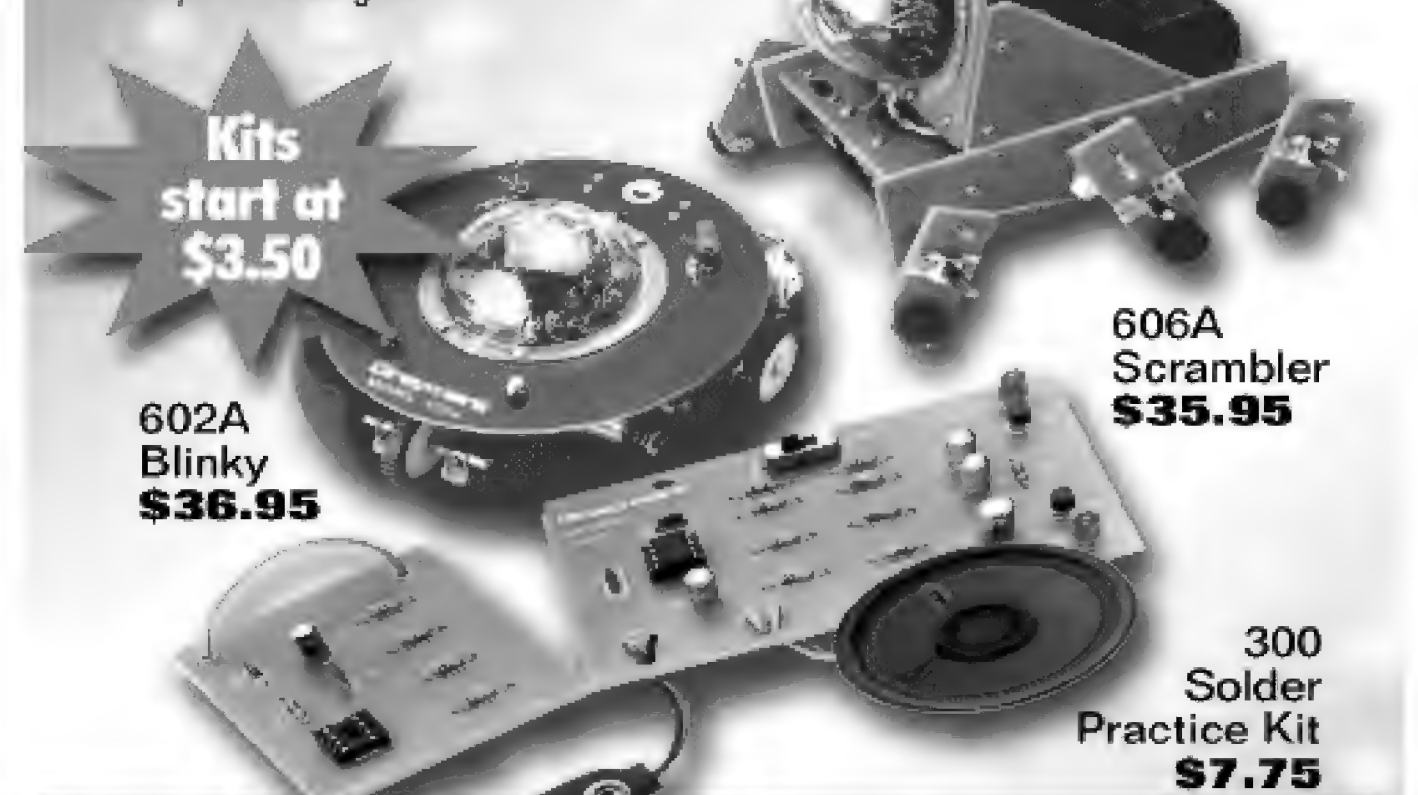
Serial

In this example (Figure 19), I set Port 1 to monitor the output of a microcontroller I/O port as it sends the value

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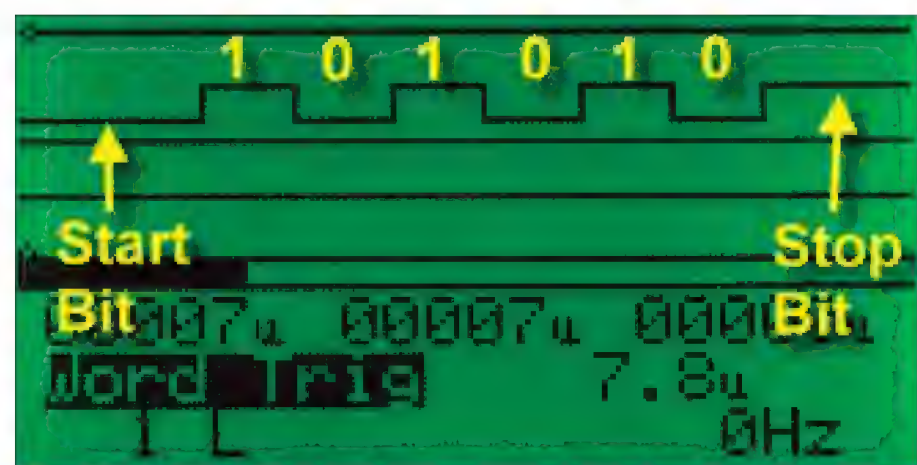


Figure 19

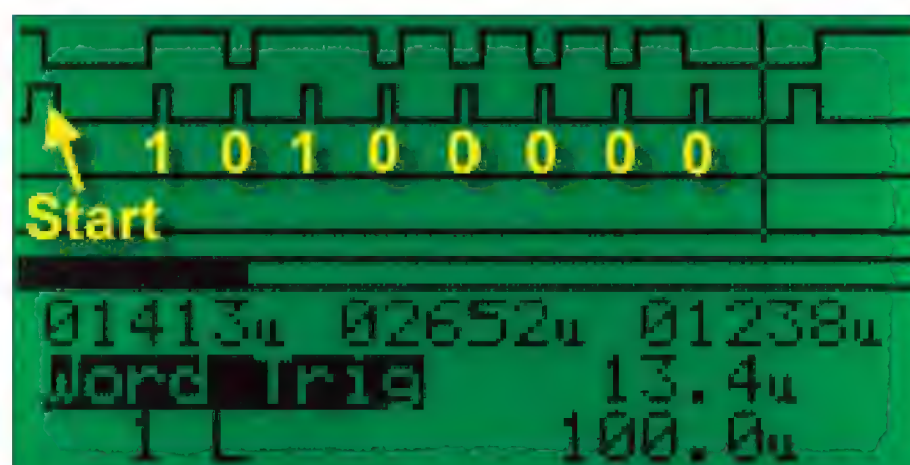


Figure 20

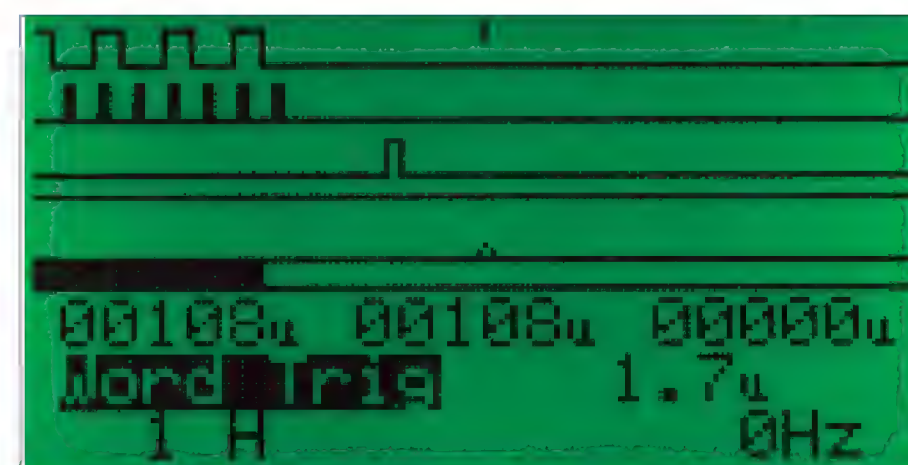


Figure 21

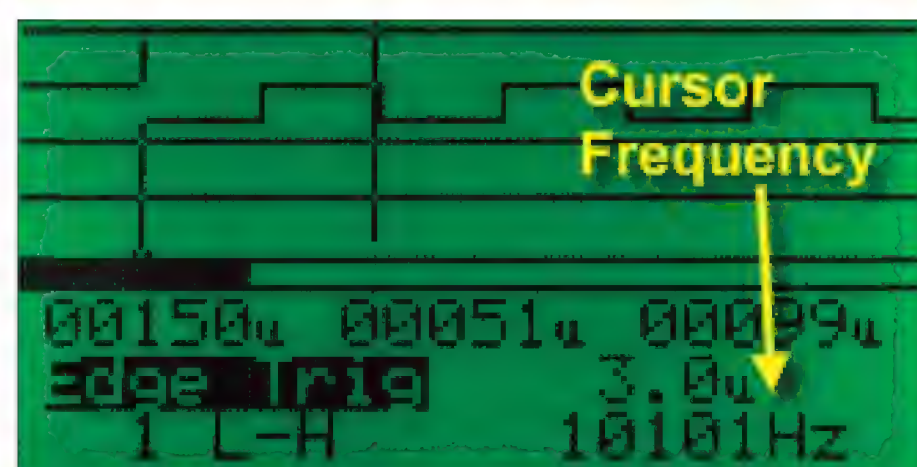


Figure 22

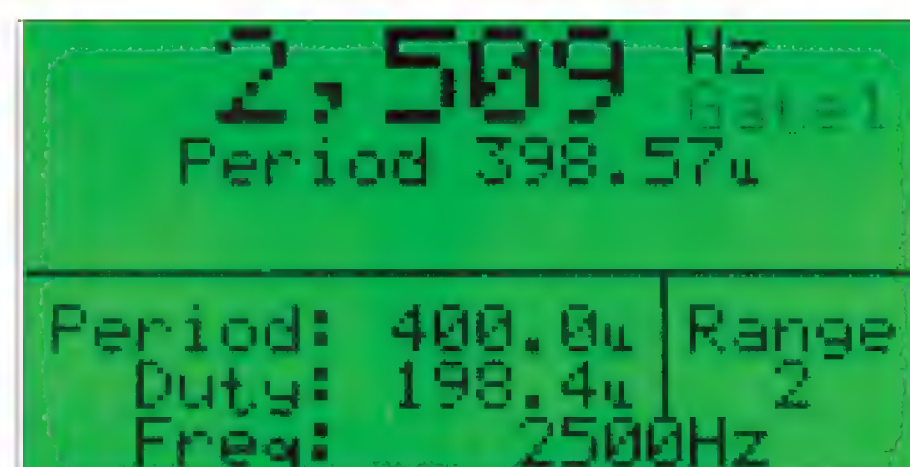


Figure 23

of 170 at 9600 baud 8n1. Again, the word trigger for Port 1 is set to low.

I2c

This is an I2c control byte (Figure 20). The SDA line is on Port 0, the SCL line is on Port 1. You can see the start sequence followed by the control byte of 160.

SPI

This is the three control lines connected to a 74HC595 serial shift register (Figure 21). Port 0 is connected to the Serial In line. Port 1 is connected to the Clock line. Port 2 is connected to the Latch line.

One thing I noticed is that the SPI interface is the fastest interface shown. In most cases, it is very difficult to capture the clock pulses as they can be quite fast.

Pulse

For a repetitive pulse train, use the edge trigger so that the pulse train will start at the same point at each capture.

In this example (Figure 22), I took the signal line (Port 13) and connected it to Port 1. I set the Edge Trigger on Port 1 to L-H. The signal generator is set up to send a 100 uS pulse at a 50% duty cycle.

Notice that as you move the cursors it will display the calculated frequency based on the period measured.

Extra

I have written a little program I call Frequency Counter as an example of the kinds of programs you can write.

The program is located in the projects/UUM directory and is called FreqCounter.txt. Program this into the

controller (prog/debug 2). Make sure you still have the Serial LCD on the first controller.

This is a frequency counter with three automatic gate ranges. It also gives you access to the signal generator. The input to the frequency counter is on Port 15. The output of the signal generator is on Port 13.

Final Thoughts

Pods

I create small pods that connect to the exposed headers. These are nothing more than small female headers with leads or components connected to the pins. These pods are removable so that I can add other pods for other experiments. For instance, I have a small pod with a DS1820. This gives me a very accurate temperature gauge that I can use to calibrate other projects.

Software Upgrades

Since the UUM is programmable, you have total control of the UUM. This project promises to be very popular and a frequently updated one, so visit the Kronos Robotics website often for updates and additional information.

Hardware Upgrades

These are unlimited. I added a larger base so I could attach a breadboard. I also added a reset button. Another easy upgrade would be to use a DiosPro in place of the standard Dios Chips. **NV**

Links

Kronos Robotics
www.kronosrobotics.com

UUM forums
www.kronosrobotics.com/forums/viewforum.php?f=16

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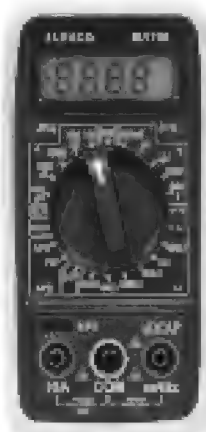
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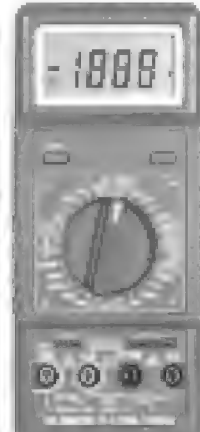
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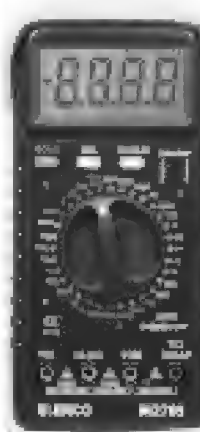
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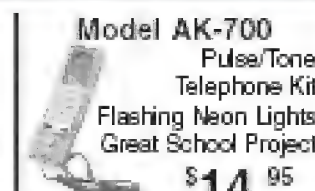
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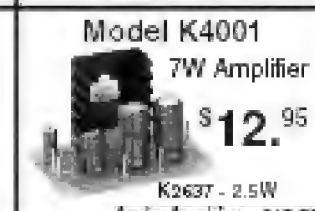
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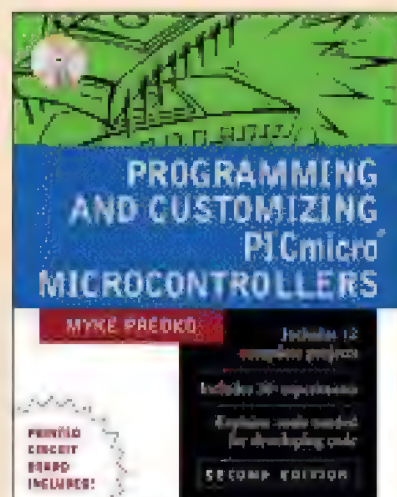
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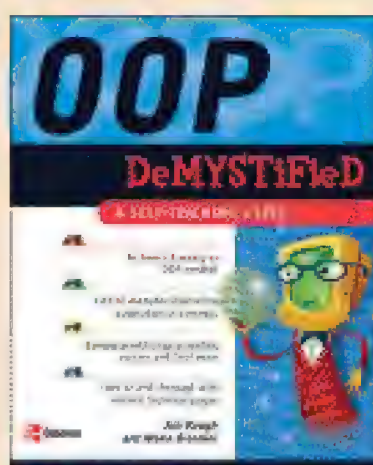
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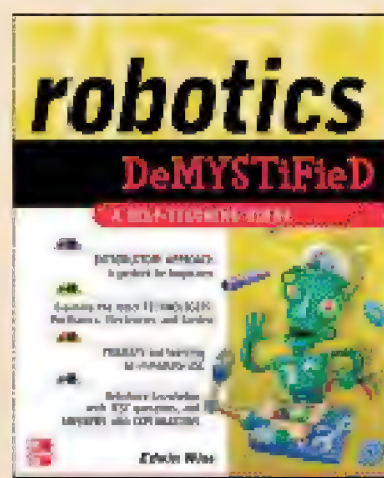


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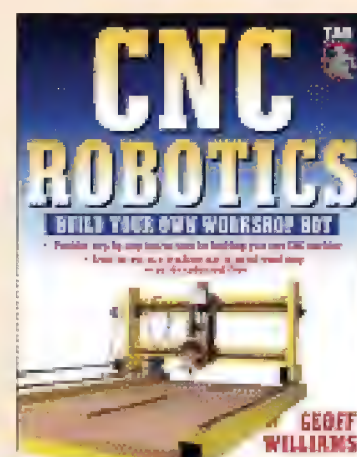
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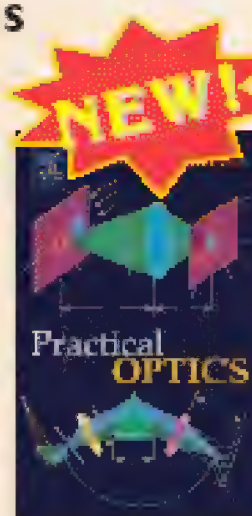


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by Naftaly Menn

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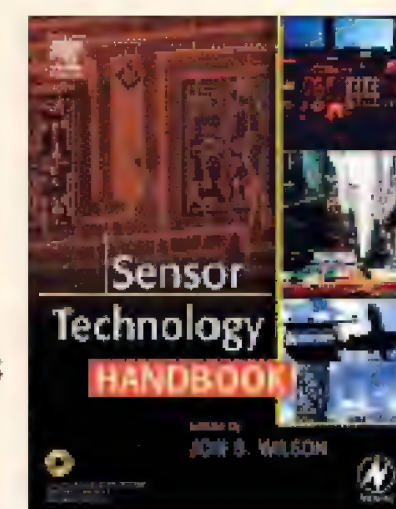
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Sensor Technology Handbook

by Jon Wilson

Without sensors, most electronic applications would not exist. The importance of sensors, however, contrasts with the limited information available on them. This volume is an up-to-date and comprehensive sensor reference guide to be used by engineers and scientists in industry, research, and academia to help with their sensor selection and system design. It is filled with hard-to-find information, contributed by noted engineers and companies working in the field today. The *Sensor Technology Handbook* will offer guidance on selecting, specifying, and using the optimum sensor for any given application. The editor-in-chief, Jon Wilson, has years of experience in the sensor industry and leads workshops and seminars on sensor-related topics. **\$99.95**



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by Paul Scherz

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Basic Electronics

by Gene McWhorter / Alvis J. Evans

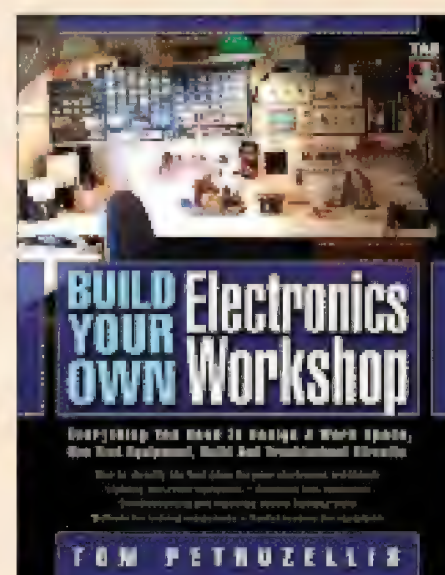
Wouldn't you like to know about the electrical or electronic effects which, many times, we can neither see nor feel? Find out how electronic circuits are used to amplify, transmit, receive and detect signals, or make decisions, or are combined to make computers, controllers, and memories. *Basic Electronics* explains electronic fundamentals using easy-to-read, easy-to-understand explanations coupled with detailed illustrations. It brings seeing and doing together for a very meaningful learning experience, and delivers practical applications at the same time. This book contains worked-out examples within the text to solidify understanding of specific ideas, and quizzes and problem sets at the end of each chapter to complete and reinforce the learning cycle. Basic concepts, device and circuit fundamentals, and circuit applications provide full-scope coverage of electronics in 11 chapters. **\$19.95**



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by Thomas Petruzzellis

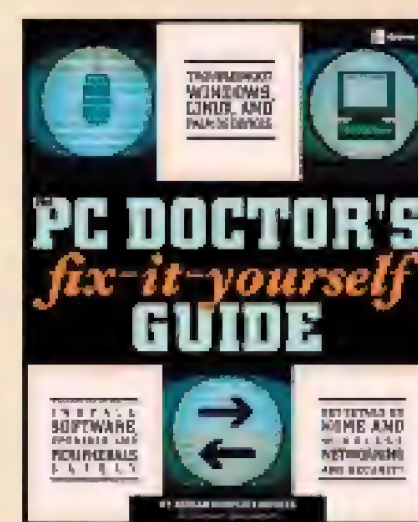
The Electronics Workbench was created to assist the newcomer in the field of practical electronics through the creation of a personal electronics workbench. It is a place specially designed so that readers can go there to work on an electronic project, such as testing components, troubleshooting a device, or building a new project. The book includes invaluable information, such as whether to buy or build test equipment, how to solder, how to make circuit boards, how to begin to troubleshoot, how to test components and systems, and how to build your own test equipment, complete with appendix & resources, etc. This is *THE* book for anyone entering the field or hobby of electronics. **\$29.95**



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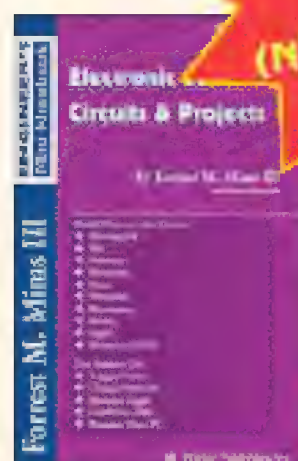
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USB Complete, Second Edition

by Jan Axelson

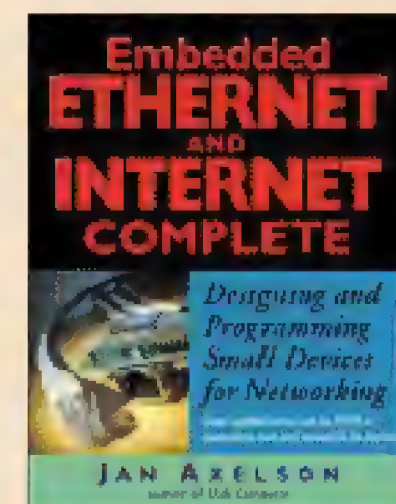
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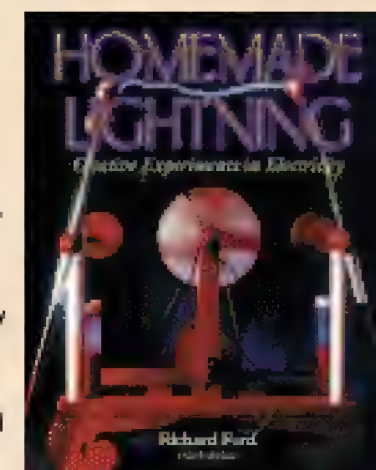


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WIRESOUNDENCE!

Imagine a world without the Internet:
no email, no chat sessions, no Usenet newsgroups, no Web. This is the world of 1951. A citizen of this world who wanted to discuss common interests, politics, or world events with others on a national or international scale had few channels to communicate through.

by David Medcalf



One promising channel was ham radio. Unfortunately, this method required an FCC license, an antenna, and the technical know-how to operate and maintain the transmitting equipment. Long distance phone calls didn't require specialized knowledge, of course, but in 1951 a call from Chicago to St. Louis cost 30 cents per minute. This was expensive, being equivalent to \$2.19 per minute in today's dollars.

Letter writing was not yet a dying art in 1951, but, just as with email today, letters lacked the expression of voice (the smiley face, ubiquitous in today's email, had yet to be invented). Voice recordings were a more powerful alternative, and inexpensive compared to long

distance calls.

By 1940, consumers could create their own sound recordings using record cutting machines. Portable units were available, combining the record cutter with a regular phonograph and radio. Record blanks were made of acetate or lacquer-coated metal disks and, by 1950, could hold up to 40 minutes of speech and music. Messages could be sent to anyone who had a record player, from family and friends, to servicemen overseas. Unfortunately, record cutters were write-once devices — once the disk was cut, no changes could be made to the message.

The magnetic wire recorder, ancestor to the tape recorder, had undergone great development during World War II. By the late 1940s, wire recorders

Photo 1. A wire recorder is sitting on the desk to the left. This exhibit is dedicated to the Roswell Incident of July 4, 1947, at the International UFO Museum and Research Center in Roswell, NM. Photo courtesy of the International UFO Museum and Research Center.



Photo 2. Model 181, to the left, cost about \$100.00 and featured a Magic-Eye tube as a recording level indicator. Model 228, to the right, was designed for business dictation. Webster-Chicago made several variations of its basic models. These units, and the Silvertone models shown elsewhere, are on display at the Museum of Radio and Technology, Huntington, WV. Photo courtesy of Richard Post.





Photo 3. This is a Silvertone combo unit, manufactured by the Colonial Radio Corporation for Sears, Roebuck and Company. The rim of the turntable acts as the takeup reel for the wire recorder. Photo courtesy of Richard Post.



Photo 4. This is the wire recorder portion of a Silvertone console unit, containing a separate phonograph and radio. The recorder could be controlled by the clock/timer on the front, allowing radio programs to be recorded while the listener was absent. Photo courtesy of Richard Post.

were available in consumer equipment. Sears, Roebuck and Company sold at least two "Silvertone" combination models that included a wire recorder, phonograph, and radio. Wire recorders solved the editing problem inherent with cutting records, as parts of messages could be deleted or recorded over. Playback quality could be checked while a recording was being made, and separate wire recordings could be spliced together, as well. A spool of stainless steel recording wire was more expensive than a record blank, but could

hold over an hour of audio.

Recording a message on a wire spool and mailing it off to family and friends became a growing fad called "wirespondence." Webster-Chicago, a company that produced audio equipment including wire recorders, created the Wirespondence Club in 1950. This effort was spearheaded by John Schirmer, an employee of Webster, who saw the power of corresponding by audio recordings. In 1948, the Soviet Union blockaded West Berlin where Schirmer's mother lived. During the massive US and British airlift supply campaign, one of the pilots ordered a wire recorder from Webster. Schirmer, being in the export

RESOURCES

During the 1940s and 50s, the wire recorder gained popularity as a tool for news reporters and as an entertainment device for consumers. These machines can now be found occasionally at ham-fests and on online auction sites. Advice for repairing recorders and splicing wire recordings can be found at the Video Interchange website:

www.videointerchange.com/wire-recorder1.htm

Webster-Chicago was a major manufacturer of wire recorders from the mid-40s to the early 50s. Schematics and period prices of their major models can be found at:

www.webster-chicago.com

Recording wires were commonly made of stainless steel, and so many recordings have survived to the present. Examples that have been converted to MP3 format are available at:

www.coolcatdaddy.com/rand/wires.html

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Photo 5. This is a Webster-Chicago Model 80, one of the most popular wire recorders available in the late 40s. It originally retailed for around \$150.00. The stainless steel recording wire is extremely thin and could kink into a tangled mess easily. To help prevent this, the recording head oscillates vertically to bail the wire smoothly onto the reels. Photo courtesy of the International UFO Museum and Research Center.

department, recorded a 15 minute message for his mother and shipped the spool along with the recorder. Thanks

to the pilots, a flow of recordings to and from blockaded Berlin began.

In the first three months of the formation of the Wirepondence Club, membership had reached 830, with members representing 20 countries besides the United States. By late 1952, the Club had grown to over 1,900 members from 35 countries and all 48 states (Alaska and Hawaii had not yet achieved statehood). Members came from all walks of life, including scientists, ministers, farmers, artists, and bankers. Topics of interest were wide-ranging, involving politics, language, music, and descriptions of the scenery in the sender's local area.

At least two marriages are reported as having originated from wirepondence (just as has resulted from Internet chat sessions today). Municipal and religious leaders of Springfield, MA, sent a spool of friendly greetings to the townspeople of Shiremoor, Northumberland, England, as an expression of fellowship to members of our World War II ally. A wirepondent told a United Nations *World Magazine* reporter, "You learn to understand and like people of different background. Your horizons extend and you lose the idea that your country and your way of living is the only one."

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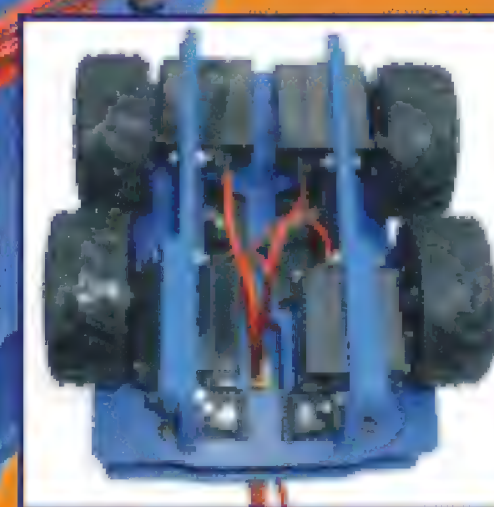
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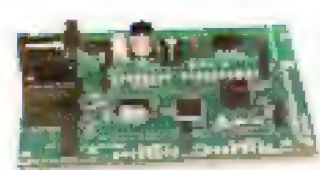
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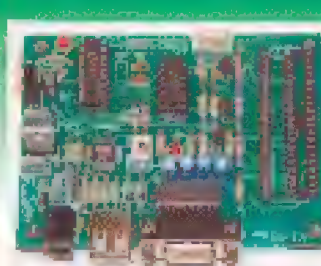
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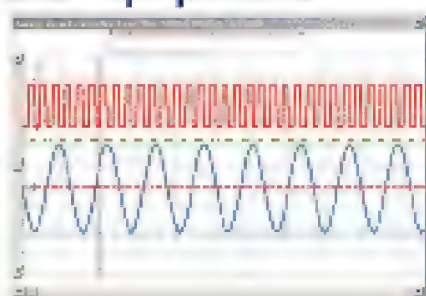
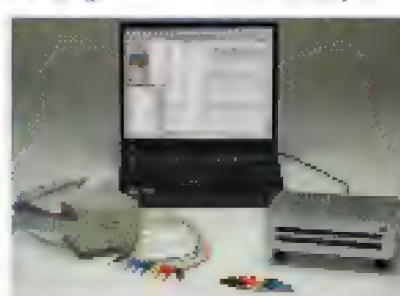
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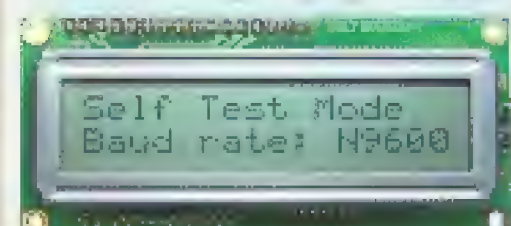
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Taking the Teeth Out of Bluetooth Phracking



THE CRYPTOPHONE PSTN/1, GSMK'S SECURE LANDLINE PHONE THAT IS FULLY INTEROPERABLE WITH GSMK'S SECURE CELLULAR AND SATELLITE PHONES.

Paris Hilton's hijacked phone notes, hot pics and movies, and celebrity contact info got her unwanted and undeserved notoriety. The incident also brought broad visibility to a blossoming dilemma: like computer data, our increasingly computer-like mobile phones' contents can be hacked. **by David Geer**

To be correct, your data can be phracked. Phracked, phracking, or phracker are the correct terms for a phone cracker or phone cracking. Cracking is the correct term for malicious hacking.

Following the classic security mantra of using layered protection, we present several counter-hacks that untethered communicators can use to foil the would-be phracker.

BLUETOOTH SECURITY — BLUETOOTH BACKGROUND

Bluetooth is a fairly recent technology that has faced its share of invasions. Notable attacks have included Blue Stumbling, Blue Snarfing, and Blue Jacking.

Blue Stumbling is the Bluetooth equivalent to War Driving*. By using Blue Stumbling, phrackers (phone

crackers) can pinpoint Bluetooth gadgets (PDAs, Mobile Phones) within a small radius.

*(*With War Driving, a cracker drives around with a laptop and a special antenna engineered from a potato chip cylinder discovering unprotected Wi-Fi networks. Wi-Fi crackers do this so they can use your connection for free, crack another system through your connection while masquerading as you to steal data or deface websites, or simply mess with your head.*

Blue Stumbling is also referred to as War Walking.)

Blue Snarfing is a technique that permits a phracker to rob data from your Bluetooth device without pairing (making a direct connection) with it. Phrackers cannot only surreptitiously retrieve information from your Bluetooth device, but also send information to it without exposing themselves or having to be acknowledged by the recipient.

With Blue Jacking, phrackers can send information to the Bluetooth device without pairing with it so that you wouldn't know who it was from. It's a kind of Bluetooth-based version of spamming.

BOUNCING BLUETOOTH BREAK-INS

For most all the above, protection is as easy as downloading and installing the latest firmware update for your phone. Other fundamental precautions include turning off the Bluetooth service when you're not using it. If it's not running, it can't be hacked.

Insure that your phone has encryption abilities and use them. Some brands offer seamless encryption that's always on to protect your Bluetooth connections so you never have to set it (check the manual for your hardware). Nokia is such a vendor.

With Nokia Bluetooth enabled phones, the encryption is transparent to the user, always on, automatically protecting authenticated Bluetooth connections, including voice communications between a headset and phone.

Use the phone in non-discoverable mode (see your manual). When any Bluetooth device is in non-discoverable mode, it can't enter into a state where it can respond to inquiries. You can loosely think of it like not hav-



ing your wireless 802.11 router set in broadcast mode.

Create new link keys for pairing with other devices. With Nokia phones, you can create a new link key for pairing devices by deleting the existing pairing from the paired devices menu. This keeps the passkey new and unique, harder to crack.

You can also audit your phone — test its security — using Bluetooth network discovery tools like BlueSniff and RedFang. With these software downloads

LEFT: The GSMK CryptoPhone 200, the world's first secure PDA-based cellular phone.

BELOW: The CryptoPhone 200T, GSMK's secure phone for both cellular and satellite connections.



and most any Bluetooth adapter, you can use a simple interface to check for the availability of Bluetooth networks and devices (including your own).

OTHER SECURITY MEASURES – AV AND FIREWALLING

Bluetooth is by far the only phone protocol or the only phone vulnerability. For advanced devices, firewalls and antivirus protection are recommended. Using Nokia as an example, you can use products such as Symantec's integrated firewall and AV product for Nokia's 9500 Communicator and the 9300.

Both F-Secure and Symantec offer AV for the Symbian OS-based Nokia smart phones, i.e., Symantec Mobile Security 4.0 for Symbian protects Symbian operating system based smart phones (series 60 and 80) like the 9300 and 9500 from not only viruses, but also Trojans and worms. Comparable information should be available from your vendor.

MORE FROM NOKIA

Don't accept unidentified Bluetooth applications or MMS attachments. These may include phone-based malware that is harmful to your phone. Don't download content to your mobile phone from an unknown, obscure, or unreliable source. Download from your operator's (carrier's) portals or other well-known brands, where you should assume good protection against potentially harmful malware (viruses and the like).

Nokia has a VPN solution for many of its smart phones at www.nokia.com/nokia/0,,43117,00.html. A wallet feature available in many Nokia models secures sensitive e-commerce and other data. Data inside the wallet is encrypted and protected with a special access code that the phone user can define. See more at: www.nokia.com/nokia/0,8764,43153,00.html

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>>>RESOURCES

■ RAZORPOINT SECURITY TECHNOLOGIES

www.razorpointsecurity.com

Thanks to Gary Morse, president of Razorpoint, for his input on Bluetooth.

■ BLUESNIFF

<http://bluesniff.shmoo.com>

A Bluetooth network discovery tool

■ NOKIA

www.nokia.com

Thanks to Nokia for its input on Nokia mobile phone security.

■ REDFANG

www.securiteam.com/tools/5JP011FAAE.html

Another discovery tool

■ GIZMODO, THE GADGETS WEBLOG

www.gizmodo.com

■ MISC. BLUETOOTH SECURITY RESOURCES

<http://wiki.mediaculture.org.au/index.php/Bluetooth-Security>

■ BLUETOOTH WEBLOG

<http://bluetooth.weblogsinc.com>

■ BLUEZ.ORG

www.bluez.org

The Linux Bluetooth Protocol Stack

OR, JUST GET A PHONE BUILT AROUND SECURITY

The new CryptoPhones from Germany in four models are all about cryptography and security. The devices use AES256 (Advanced Encryption Standard) and Twofish algorithms for security and the 4096 bit Diffie-Helman key exchange technology.

The US Government has approved AES encryption for up to and including classified top-secret information. The 256 stands for 256 bits, the largest number of bits available to encrypt data. Twofish encryption was a top finalist for selection as the AES standard, beat out by Rijndael encryption.

The Diffie-Helman is based on RSA (the RSA algorithm invented by Ron Rivest, Adi Shamir, and Leonard Adleman, the acronym being formed by the first letters of their last names) math and enables secure key exchanges where the encryption and decryption key is the same exact key.

The CryptoPhone destroys its encryption key automatically the second the call ends. Standby time is a competitive 180 hours. Talk time using security is up to 3.25 hours on a single charge. The CryptoPhone supports GSM networks.

The CryptoPhone offers a hard line defense in the face of IMSI-catchers (IMSI stands for International Mobile

DON'T ACCEPT UNIDENTIFIED BLUE-TOOTH APPLICATIONS OR MMS ATTACHMENTS. THESE MAY INCLUDE PHONE-BASED MALWARE THAT IS HARMFUL TO YOUR PHONE.

Subscriber Identity) and network-based interception threats. An IMSI Catcher is a device for finding mobile phones (short range) and recording telephone calls. The device appears to the mobile phone to be just another base station.

The phone provides CELP (the Code Excited Linear Prediction algorithm) voice quality and you can use a free GSMK CryptoPhone for Windows client to set up secure telephony between a landline user or users and the mobile GSM CryptoPhone 200 using a computer and modem. The format and form factor resemble PDA-phones with a large display and easily maneuvered interface.

Because the phone software is based on open source code, there is no proprietary control that might create its own security issues, i.e., there is nothing concealed from the user -there are no backdoors, no operator (carrier) key generation, or registration.

The CryptoPhone is the only mobile phone on the market with the full source code published. This enables engineers and programmers to assess its security independently. If you're a developer, you can develop your own CryptoPhone compatible products using the published source code and the public, standards-based communication protocols. **NV**

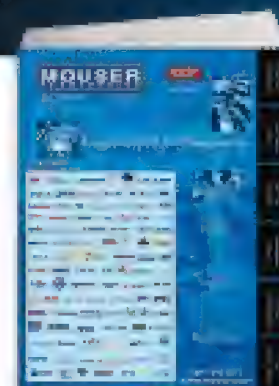
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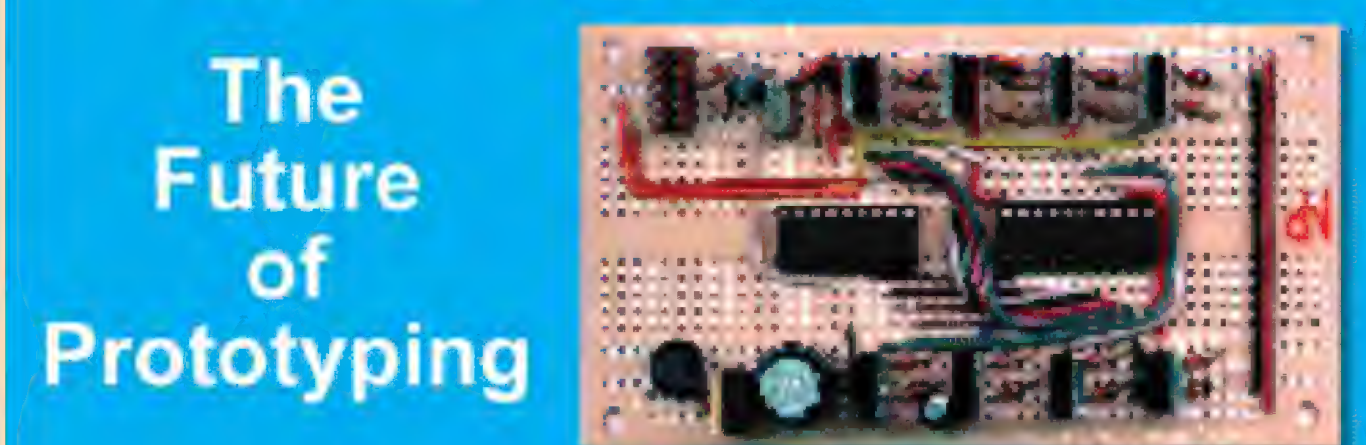
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Reader Feedback

(Continued from page 6)

scribers. Even so, one would likely be correct in assuming even they subscribe because of the hobby aspect of the magazine.

Many in the electronics field are called nerds, for good reason. They love what they do enough that they do it not only in their professions, but are also tinkerers at home.

What would be the fun in buying commercially-available units when one can build things, create working products with one's own hands?

Why would anyone subscribe to *NV* if they thought of constructing electronics projects as being a chore, or not something enjoyable to spend time upon? It seems, to me,

almost incomprehensible.

Charles Rhines
Sioux Falls, SD

Dear Nuts & Volts:

First of all, I must say that your magazine is a great magazine. It covers both projects and up-to-date market information related to electronics which is a must for people who want to keep abreast with the latest info available.

What I really want to compliment is, the people of *Nuts & Volts* really listen to their customers. I sent a suggestion to *NV* about distributing the great magazine in digital format and, Viola! I got it.

Davis Hong

Dear Nuts & Volts:

As a long time reader, and a subscriber for a few years, *NV* is my favorite magazine.

As a teacher, I find the articles useful in keeping up with advances in the field and the circuits are especially helpful in teaching our circuits, programming, and fabrication classes.

I am always looking for articles that help me teach topics that are "cutting edge" and not usually found in other typical electronics literature. Thank you for a truly useful magazine!

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EU Proposes System for On-line Music

The European Commission has proposed a single Europe-wide copyright and licensing system for on-line music to boost the European Union's music business.

EU Internal Market Commissioner Charlie McCreevy said European on-line services had to be improved to make copyrights cheaper for artists to obtain.

"We have to improve the licensing of music copyright on the Internet," McCreevy said, adding such a system would ensure "Europe's creative community will get the lion's share in revenues achieved on-line."

Currently artists have to secure copyrights in each of the EU's 25 member nations, with each country requiring separate copyrights for the right to transmit songs over the Internet, a complex and expensive process, the EU head office said.

As a result of these costs, on-line music sales in Europe have lagged behind those in the United States. Last year, the US had an estimated \$248 million in on-line music sales compared with Europe's \$32.5 million.

Musicians make money from their music after registering copyrights with collective rights managers. Those managers then license songs to on-line services, radio stations, dance clubs, and other outlets. All these registrations are complex and cost artists a lot of money.

The EU head office said a single system governing music rights would save money.

"The most effective model for achieving this is to enable right-holders to authorize a collecting society of their choice to manage their works across the entire EU," said the Commission in a statement, adding such a system would "considerably enhance" earnings for artists.

Sasser Creator Avoids Jail Term

A German youth has been given a 21-month suspended sentence after being convicted of creating the Sasser worm which crippled computers worldwide.

Sven Jaschan was found guilty of computer sabotage and illegally altering data, said a court official.

He evaded a jail term as he was tried as a minor since he was 17 years old when he wrote the worm.

Sasser wrought havoc when the Windows worm struck in May 2004, swamping net links and making computers unusable. Jaschan had admitted to creating the worm at the beginning of his trial, reiterating a

AUGUST 2005

confession to authorities at the time of his arrest in May 2004.

Keystroke Logging a No-No in Alberta

A Privacy Commissioner's ruling against an Alberta library that electronically monitored an employee's computer use means employers have lost one objective way of measuring workers' performance, says the library's director.

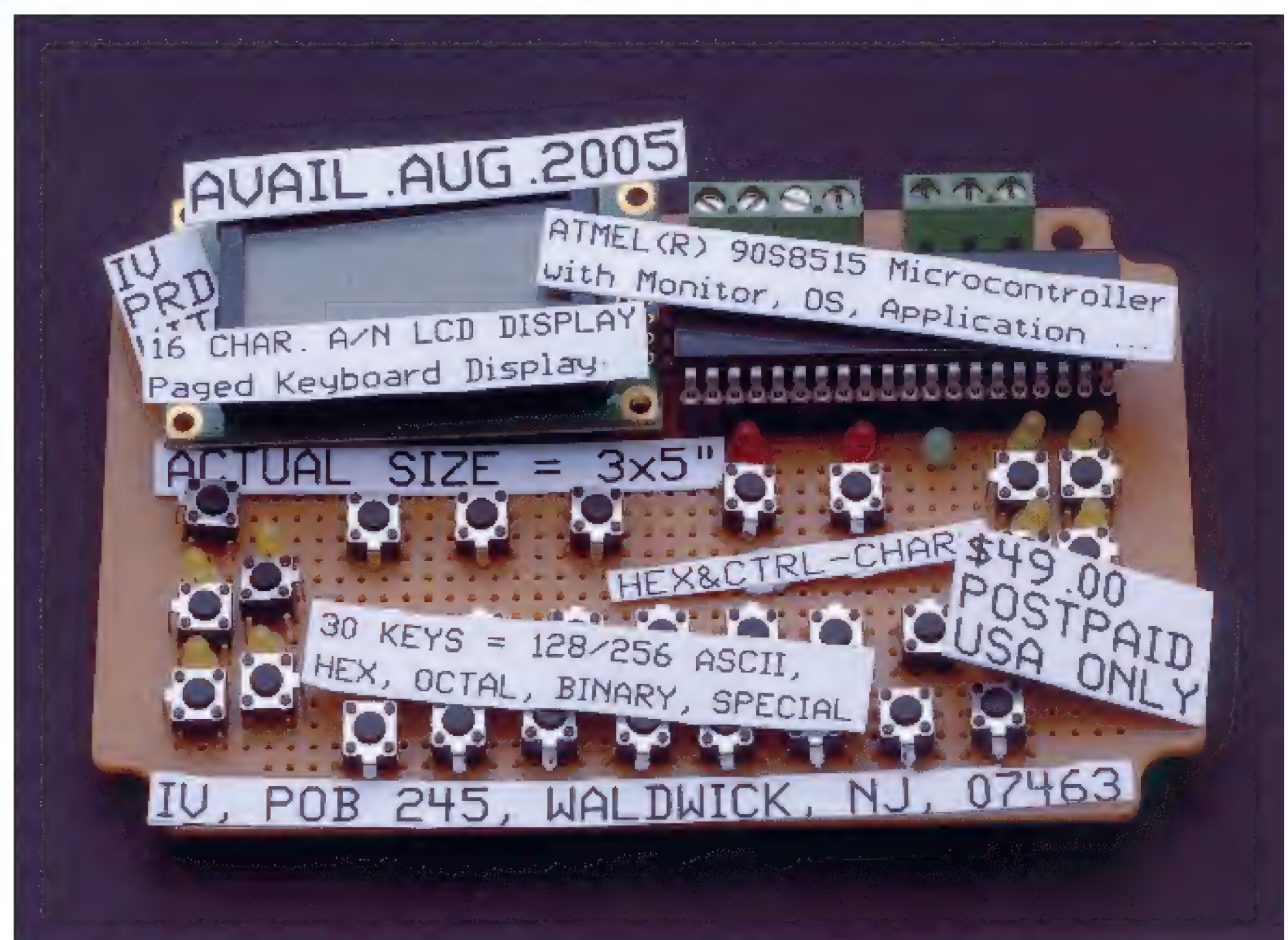
Patricia Silver, director of the Parkland Regional Library in Canada, ordered the installation of keystroke logging software on the computer of an employee whose productivity was questioned. When the employee discovered that he had been monitored, he lodged a complaint with Alberta's information and privacy commissioner.

In a decision released last week, Commissioner Frank Work ruled that the library collected personal information about the employee in contravention of the Freedom of Information and Protection Privacy Act.

The employee, who was not named, worked as a computer technician for six months in 2004. Ms. Silver said it was a job where productivity was hard to measure.

"We thought that using an objective check through the computer would be the most fair and objective way to do that," she said.

Ms. Silver disputed Mr. Work's finding that the library collected personal information on the employee, saying managers never looked at any of the computer files that were logged. She said she believed the keystroke logging would be allowed under a clause in the act that permits collection of information that is necessary for an operating program or activity of a public body.



Advanced Techniques for Design Engineers

The Design Cycle

Focus on the FLASH (Atmel AT49LV1025)

Integrating large FLASH and SRAM into microcontroller designs has become a must-know technique with the advent of microcontroller-based LAN devices. Sometimes an EEPROM just isn't enough to hold all of those web pages you want to serve from your little PIC-based or AVR-based web server. If you're collecting data, a large FLASH part is nice in that you can store away those accumulated readings and retrieve them intact, even if the batteries go bye-bye on your microcontroller-based data collection device.

A large SRAM device comes in handy when you need to temporarily store and process large arrays of data. For instance, you can build a

number of maximum size Ethernet frames in a large SRAM buffer and call upon them to be sent at will.

This spin of "Design Cycle" will focus on the Atmel AT49LV1025 FLASH IC and how to use it with a PIC. When you're finished reading this column, you'll know how to tie an Atmel AT49LV1025 FLASH IC to a PIC and code an AT49LV1025 driver. The AT49LV1025 interface knowledge you will gain here can also be easily applied to AVR microcontrollers.

I coded the AT49LV1025 driver for this column using C and the HI-TECH PICC-18 C compiler. However, that's not a show stopper. The C code I'll provide can easily be ported to any PIC or AVR BASIC language, as well. That's

the beauty of C. Let's begin by taking a walk around the AT49LV1025.

The AT49LV1025

The AT49LV1025 is a 3V read/write FLASH IC that does not require any additional high voltages for programming the FLASH memory cells it houses. The AT49LV1025 is designed to be programmed, erased, and read while in-system.

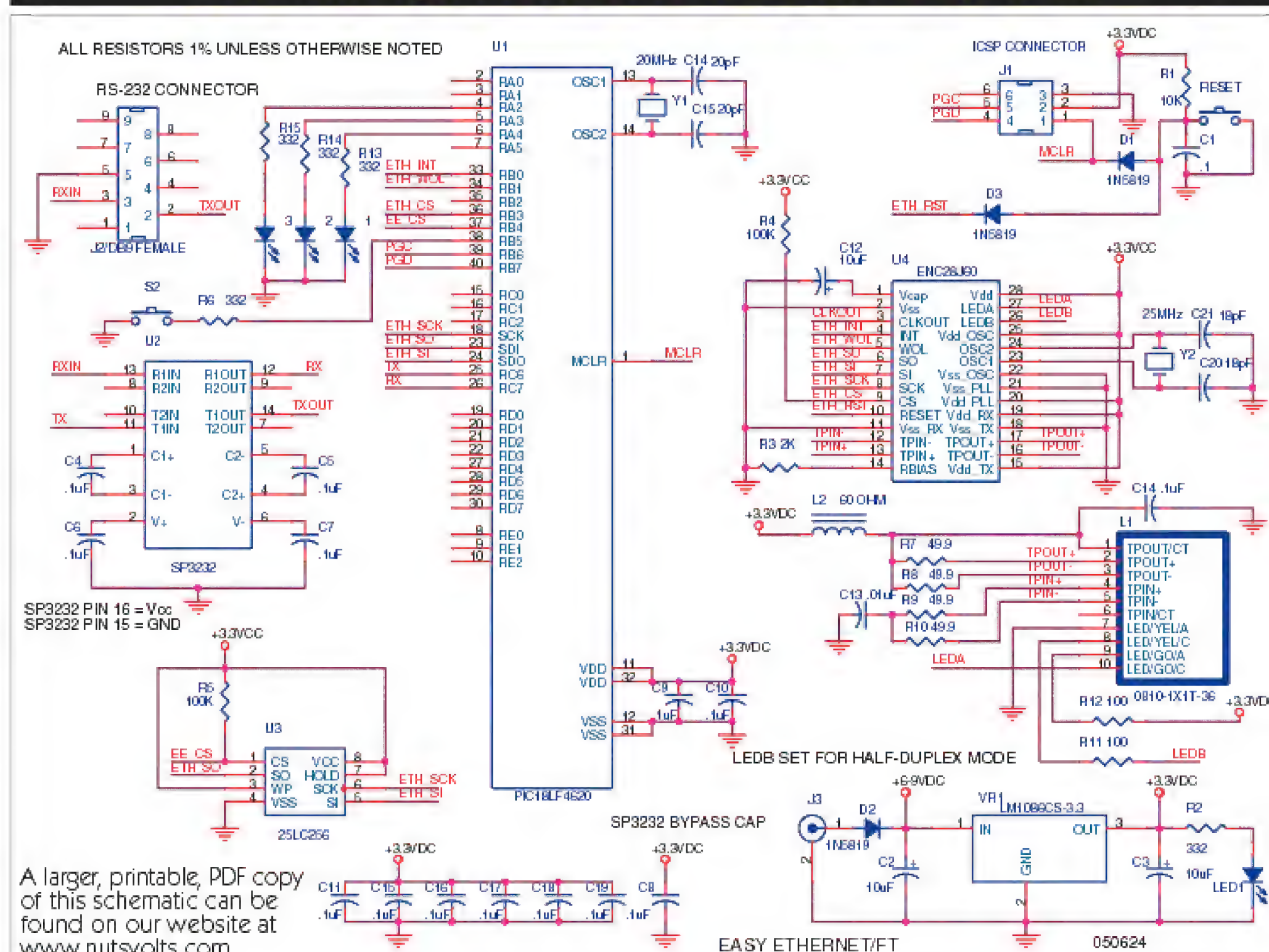
Logically, the AT49LV1025 is an EPROM that doesn't have to be removed from the system circuitry to erase and reprogram. The read access time of the AT49LV1025 ranges from 55nS to 90nS, depending on the grade of part you design into your project. I have selected the 90ns AT49LV1025 for this application.

The AT49LV1025 is the 44-pin PLCC-packaged first cousin of the AT49LV1024, which is housed in a 40-pin SMT VSOP package. The only difference in the AT49LV1025 and the AT49LV1024 is their packaging.

Erasing and programming the AT49LV1025 is accomplished using commands issued by the microcontroller that is in charge. An AT49LV1025 word write cycle is nominally 20uS long. The end of a program cycle can be sensed using one of two end-of-cycle features of the AT49LV1025, Not-Data Polling or Toggle Bit sensing.

If writing delay loops is your thing, you can also just kill 20uS between write operations. To use Not-Data Polling, the programmer

Figure 1. No rocket science here. This is a typical PIC microcontroller layout complete with ICSP programming/debugging port, serial port, and power supply. The AT49LV1025 is wired in according to the rules of the PIC's Extended Memory Interface.



issues a write command and immediately reads the address that was just written to. If the program cycle is in process, a complement of the seventh data bit of the data written to the location being read will appear on the AT49LV1025's I/O7 pin.

The complement of the seventh bit of data is where the "Not" in Not-Data comes from. Once the program cycle completes, 16 bits of true data can be read from the just-programmed location and the "Not" bit on I/O7 reads as the true value of bit 7.

The Toggle Bit sensing technique alternates pin I/O6 between a logical high and a logical low (1 or 0) while the program cycle is in process. When the program cycle completes, the I/O6 pin ceases to toggle and valid data will appear on the AT49LV1025's data I/O pins. The AT49LV1025 firmware written for this "Design Cycle" run will use the Not-Data Polling technique to determine the end of a program cycle.

The AT49LV1025 is a one-megabit FLASH device arranged as 64K x 16. The 64K (0xFFFF) of memory space can be optionally allocated as 8K (0x0000-0x1FFF) of Boot Block memory with the remainder of the 64K space (0x2000-0xFFFF), called Main Memory, left to be used at the programmer's discretion for machine instructions or data storage. If you choose not to employ an 8K Boot Block, the entire 64K of AT49LV1025 memory space can be considered logically as Main Memory.

The 8K Boot Block area can be write protected, which allows the remaining 56K of Main Memory area to be updated without fear of overwriting the 8K Boot Block area. However, you can run with an unprotected Boot Block and still maintain a logical distinction between the Boot Block and the Main Memory.

Two FLASH erase commands make this possible. The Chip Erase command initiates an erase of the entire 64K memory area, while the Main Memory Erase command only erases the Main Memory area beginning at address 0x2000. AT49LV1025 memory areas are programmed one

word at a time and have a minimum endurance of 10,000 program cycles.

There's one caveat to using a protected Boot Block. When you invoke what is termed Boot Block Programming Lockout via the Boot Block Lockout command, the Boot Block area can never be erased or reprogrammed again. This is done purposely to provide a high level of security for the code contained within the 8K of Boot Block memory.

Logically, accessing the AT49LV1025 is much like accessing an EPROM in that there are no special control lines to deal with. There are 16 AT49LV1025 address lines (A0-A15), which provide access to the AT49LV1025's 64K of memory space.

Since the AT49LV1025 is a 16-bit device, the AT49LV1025 is fitted with 16 tri-state-capable, bi-directional data lines (I/O0-I/O15). An active-low Chip Enable (*CE) pin coupled with an active-low Output Enable (*OE)

pin and an active-low Write Enable (*WE) pin are all the control lines needed to gain read/write access to the AT49LV1025's vast FLASH memory resources.

So far, the AT49LV1025 seems to be an easy way to add 64K x 16 of FLASH memory to a microcontroller-based system. Basically, if you've ever used an EPROM or an SRAM in a project, you can apply that knowledge to the use of an AT49LV1025.

Let's take a look at what it takes to weave the AT49LV1025 into a typical microcontroller design.

Some FLASH-Based Microcontroller Hardware

An AT49LV1025-based project can be assembled from scratch using through-hole, point-to-point, or SMT wiring techniques. I always test production designs with prototype

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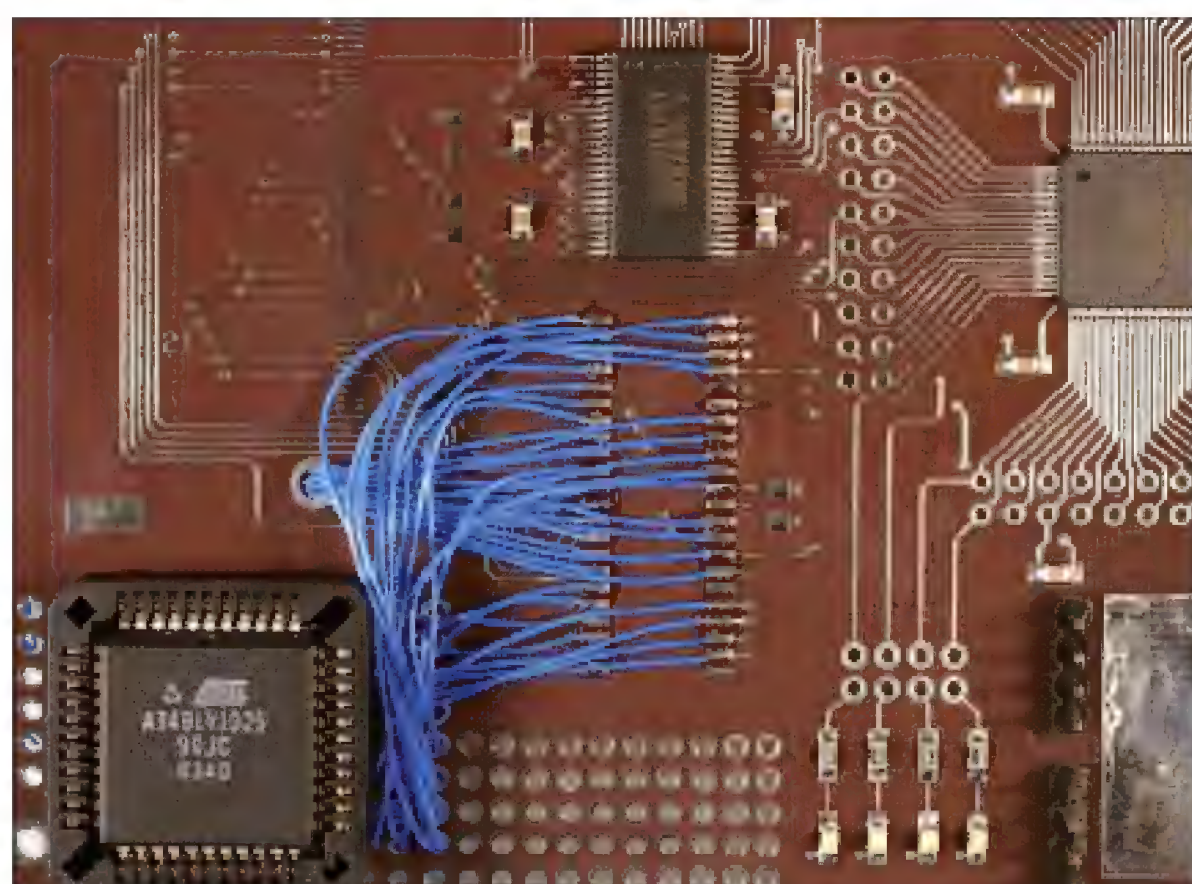


Figure 2. Believe it or not, during the SOJ-to-PLCC wiring process, I only made a single wiring error! The 74LVTH16373 16-bit latch is just above the SOJ pad area and the PIC18LF8621 is in the upper right of the shot. Four LEDs and their associated current limiting resistors are also shown in this photo.

printed circuit boards (PCBs) before committing to a final production printed circuit board run. So, I always have a few fully-loaded prototype PCBs lying around that I can use for projects like this.

The prototype board I've chosen to use for the AT49LV1025 FLASH application is based on a 3.3-volt PIC18LF8621 running at 20 MHz. The wiring scheme of the prototype board I will use is shown graphically in Figure 1. There's nothing hardware here that you haven't seen before. The 74LVTH16373 is a three-volt, 16-bit transparent latch, which could easily be a pair of socketed 74LVTH573 octal transparent latches in your design.

The PIC18LF8621 is capable of switching the PortD, PortE, and PortJ I/O pins between EMI (External Memory Interface) and standard I/O modes. When the PIC18LF8621 is operating in Extended Microcontroller Mode, Table Read (TBLRD) and Table Write (TBLWR) instructions can be used to access bytes within the EMI address space (0x10000 to 0x1FFFE for the PIC18LF8621).

The physics of the AT49LV1025 do not allow the use of the PIC18LF8621's Table Read/Write instruction set, as a byte within a word cannot be gleaned directly from the AT49LV1025's 16-bit data bus. However, I decided to wire in the

AT49LV1025 as if it could use the PIC18LF8621's Table Read/Write instruction set anyway.

Even when running in Extended Microcontroller Mode, I can switch off EMI and use standard I/O coding to access the AT49LV1025. Your application may require a mix of SRAM and FLASH. If it does, this is the way you want to wire in the AT49LV1025 as you can then choose your memory access method (EMI or standard I/O), depending on the memory device you are accessing at

the time.

The PIC18LF8621-based three-volt prototype PCB I selected natively supports a 64K x 16 SRAM in a 44-pin SOJ package and its companion 16-bit 74LVTH16373 transparent latch. As you can see in Figure 2, I had just enough breadboard area to slip in a 44-pin PLCC socket to house the AT49LV1025. I wired the AT49LV1025's 44 PLCC pins to the corresponding 44-pin SOJ pads using wirewrap wire. That's about as exciting as the hardware gets. So, let's check out AT49LV1025 driver firmware.

Accessing the AT49LV1025

The easiest way to understand the AT49LV1025 firmware is to take it function by function. So, let's begin with the least complex function: reading the AT49LV1025. The read_flash function writes the desired address to the 74LVTH16373 16-bit address latch and reads in the resulting data, which it returns to the read function's caller. The read_flash function begins by configuring PortD and PortE for output with the TO_FLASH macro.

Once the I/O ports are configured, the 16-bit address specified in the function call is converted into a pair of bytes that are sent to the

PortD/PortE port pair, which, when logically combined, make up a 16-bit I/O port. Raising the active-high ALE line from logical 0 to logical 1 opens the transparent latch and places the 16-bit address on the AT49LV1025's address pins.

After a small delay, the ALE pin is returned to a logical low state and the address data that was passed through the 16-bit latch is latched on the output pins of the 74LVTH16373 which, in turn, effectively latches the address onto the AT49LV1025's address pins.

At this point, the AT49LV1025 is addressed and ready for a read or write operation. The FROM_FLASH macro configures the PortD/PortE I/O port pair for input operation. To read a memory location, the AT49LV1025 *CE and *OE pins must be brought logically low while the AT49LV1025 *WE pin remains logically high. This is accomplished with the clr_CE and clr_OE macros.

Running at 20 MHz, the NOP() instruction expends 200nS of time. We only need 90nS of read access time, as we are using a 90nS AT49LV1025. So, a single NOP() instruction suffices for our read access time. Immediately following the 200nS of read access delay, the read_flash function inputs 16-bits of data in two eight-bit chunks and returns the *CE and *OE pins to their inactive logically high states. The two eight-bit chunks of data are then combined into a 16-bit data word by the make16 macro and the incoming data word that was just read is returned to the caller.

Writing to a memory location within the AT49LV1025 is very similar to reading a word from the AT49LV1025. The write_flash function begins in the same manner as the read_flash function by parsing the 16-bit address into a pair of bytes and latching the address out onto the 74LVTH16373 latch outputs.

At this point, instead of preparing the PortD/PortE I/O port pair for input duty, the data word to be written is split into two bytes and placed on the PortD/PortE I/O port pair.

The PortD/PortE I/O port pair is in output mode thanks to the initial TO_FLASH macro call. Again, the active-low AT49LV1025 *CE pin must be taken to a logically low level.

However, instead of using the AT49LV1025 *OE pin, the write_flash function employs the PIC's active-low *WRH pin, which is physically connected to the AT49LV1025's *WE pin. WRH is the EMI term for WE. The write pulse is required to be a minimum of 70nS wide. The shortest time we can expend is 200nS with a NOP() instruction.

So, once again a single NOP() works for our write pulse width time, which ends when the AT49LV1025's *CE and *WE pins are returned to their inactive logically high state. For consistency, the PortD/PortE I/O port pair is always configured as input upon entry to any of the AT49LV1025 read/write functions.

A write operation changes 1s to 0s in the AT49LV1025 FLASH cells.

Since a 0 can't be reprogrammed to a 1, the entire block of FLASH memory must be erased before any reprogramming can occur.

If you are not implementing a protected Boot Block, the erase function with a chiperase argument can be used to erase the entire 64K FLASH memory area within the AT49LV1025. Six FLASH write cycles make up the Chip Erase command which, when issued, results in the erasure of the entire 64K of AT49LV1025 FLASH memory.

Each write cycle of the Chip Erase command must contain the particular address and data values as shown in the erase function listing. Note that we call upon the write_flash function to perform the six Chip Erase command write cycles. The AT49LV1025 datasheet states that once the Chip Erase command is issued, the erase cycle will complete within 1.5 to 5 seconds.

To meet the erase cycle time criteria, a one-second interval timer is incorporated into the erase function. Take a look at the one-second Interval Timer Definitions area of Listing 1 (go to the *Nuts & Volts* website for Listing 1; www.nutsvolts.com) and let's see what makes the one-second interval timer tick.

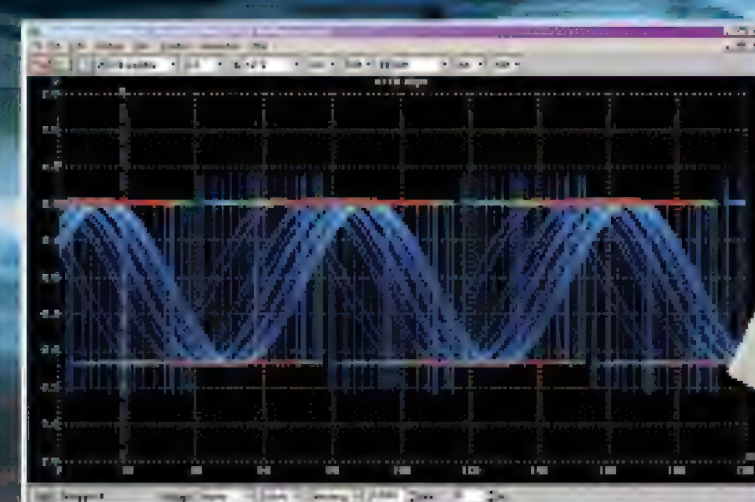
The CLOCK_FREQ value is a given in that we know our PIC18LF8621 clock is based on a 20 MHz crystal. By selecting 100 ticks per second, we have specified a 10mS (.01 second) tick time without introducing fractions into the mix. Let's assume that we haven't decided on a prescaler or a prescaler value yet. Assigning a 1 to the TICK_PRESCALE_VALUE negates any multiplication factor that would be offered by the TICK_PRESCALE_VALUE variable.

Timer0 is configured as a 16-bit counter in that the T0CON register's sixth bit (T08BIT) is clear. T0CON is

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Display Boot Block Memory
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Data at 0x0001 = 0xFFFF
Data at 0x0002 = 0xFFFF
Display Main Memory
Data at 0x2000 = 0xFFFF
Data at 0x2001 = 0xFFFF
Data at 0x2002 = 0xFFFF
Writing 0x1234 to FLASH address 0x0000
Writing 0x1235 to FLASH address 0x0001
Writing 0x1236 to FLASH address 0x0002
Data at 0x0000 = 0x1234
Data at 0x0001 = 0x1235
Data at 0x0002 = 0x1236
Erasing Main Memory..
Data at 0x2000 = 0xFFFF
Data at 0x2001 = 0xFFFF
Data at 0x2002 = 0xFFFF
Writing 0x5678 to FLASH address 0x2000
Writing 0x5679 to FLASH address 0x2001
Writing 0x567A to FLASH address 0x2002
Display Boot Block Memory
Data at 0x0000 = 0x1234
Data at 0x0001 = 0x1235
Data at 0x0002 = 0x1236
Display Main Memory
Data at 0x2000 = 0x5678
Data at 0x2001 = 0x5679
Data at 0x2002 = 0x567A
    
```

Figure 3. Now you know enough about the AT49LV1025 to put the AT49LV1025 driver firmware to work in your project. This little demo shows how the data in the unprotected Boot Block is untouched by the Main Memory Erase command.

set to a value of 0x8F in the main module of Listing 1. Bit 3 of T0CON (PSA) is set, which means that the PIC18LF8621's prescaler is not in the Timer0 clock input loop.

Being a 16-bit counter, Timer0 will count from 0x0000 to 0xFFFF and roll over to 0x0000 continually. Every time Timer0 rolls over, we can choose to generate a timer overflow interrupt.

A tick in the one-second interval timer code occurs every time we

sense the interrupt caused by the Timer0 overflow. The idea here is to set Timer0 to roll over every 10mS or 100 times per second. We will poll the TMR0IF flag bit to determine when a Timer0 rollover, and thus a tick, has occurred.

A PIC instruction cycle consists of four oscillator clock periods. With a 20 MHz clock, each oscillator clock period is equal to the reciprocal of 20 MHz or 50nS. Thus, one instruction cycle time at 20 MHz is equal to 200nS. Timer0 increments on every instruction cycle time, or every 200nS.

To get the frequency associated with the 200nS clock period, we simply invert 200nS. That comes out to be 5 MHz, which is also the Timer0 clock frequency. In our AT49LV1025 code, `CLOCK_FREQ / 4` is just

another way of representing the Timer0 clock frequency of 5 MHz. Okay, we know that Timer0 is incrementing at five million counts per second. We want to know how many counts at 5 MHz it takes to consume 10mS. In other words, we want 1/100 of 5 MHz. We can multiply 5 MHz by .01 or simply divide 5 MHz by 100.

Since it's easier not to introduce fractions into our formula, we'll divide 5 MHz by our `TICKS_PER_SECOND` value of 100. That comes to a round 50,000 counts for every 10mS. We only want Timer0 to count 50,000 times before rolling over and causing a tick. So, we need to load Timer0 with our calculated `TICK_TIMER_VALUE` of 0x3CAF or 15,535 decimal (65,535 - 50,000) and let it start incrementing from there.

At every Timer0 rollover, we must reload the Timer0 registers with 0x3CAF to maintain our 10mS tick time. The 50,000-count value works because 50,000 is less than 65,535. If our calculated `TICK_TIMER_VALUE` was equal to or greater than 65,535, we would have to employ the services

of the prescaler. Let's assign a `TICK_PRESCALE_VALUE` of 256 and see what happens.

To use the Timer0 prescaler and assign a prescale value of 256, we must clear the PSA bit by setting T0CON's value to 0x87. The three least significant bits of T0CON specify the prescale value. With all of the prescaler bits set (0x7), the prescale value is 1:256. We already know that the 10mS tick point is 50,000 counts.

Now, with the prescaler set for 1:256, each Timer0 count occurs at every 256th clock. To get our new prescaled `TICK_TIMER_VALUE`, we must divide our original 50,000 count by 256. The result — ignoring the fractional value — is 195. So, we load Timer0 with 65,535 - 195 decimal, or 65,340 decimal (0xFF3C).

The Timer0 prescaled 10mS value is radically different from the nonprescaled value, but it's still 10mS per tick in the end. I've inserted a global variable called `global_variable` into the AT49LV1025 driver code to catch and hold the calculated `TICK_TIMER_VALUE` so you can see the calculated `TICK_TIMER_VALUE` result in an MPLAB ebugging session.

Now that you know how the Timer0 tick time value is calculated, let's continue our look at the one-second interval code within the AT49LV1025 driver erase function. Following the six write cycles that form the Chip Erase command, Timer0 is loaded with the calculated `TICK_TIMER_VALUE` and the TMR0IF interrupt flag is reset. If a Timer0 rollover is detected, the TMR0IF flag bit is set and the Timer0 registers are reset to time the next 10mS interval.

Note that we aren't vectoring to a Timer0 interrupt service routine at every tick. We're simply using the Timer0 interrupt flag (TMR0IF) as a 10mS marker. When 100 ticks are accumulated, one second has passed. The elapsed seconds are collected by the `SecCount` variable, which is constantly checked against the value of the `erase_seconds` variable entered at the calling of the erase function.

Sources

Atmel Corporation
AT49LV1025
www.atmel.com

Microchip
PIC18LF8621
www.microchip.com

Texas Instruments
74LVTH16373
www.ti.com

HI-TECH
HI-TECH PICC-18 C compiler
www.htsoft.com

When SecCount is equal to erase_seconds, the erase function terminates. At this point, the AT49LV1025 memory areas should all be erased and read as 0xFFFF.

The Main Memory Erase command is also issued by code within the erase function. The only difference between the Chip Erase and Main Memory Erase command functions is the data value in the sixth write cycle.

The data value is 0x0010 for the Chip_Erase command and 0x0030 for the Main Memory Erase command. The Boot Lockout command requires 0x0040 in the data field of the sixth write cycle. I've used a C switch statement augmented by some erase function command definitions to determine which AT49LV1025 erase command to invoke.

We now know how to read and erase FLASH cells within the AT49LV1025. There's only one essential command left: Word Program.

Four write cycles are necessary to issue a Word Program command with the final write cycle specifying the actual address of the FLASH cell and the data to put into it. Immediately following the invocation of the Word Program command, a checksum is created. The checksum consists of the single true value of the seventh bit of the data specified in the word_program function call followed by zeroes (binary X0000000).

The low byte of the data word is continually checked until the bit within the checksum matches the bit in the byte that is read from the AT49LV1025. That's all there is to it!

Proof of the Pudding

Okay, we have everything we need as far as firmware is concerned to read, write, and erase the AT49LV1025. I put together some simple display memory and write memory functions using the AT49LV1025 read/write/erase firmware modules we discussed earlier.

Basically, the display memory function reads a number of words from the AT49LV1025 and sends the data

read out to the prototype printed circuit board's serial port. Conversely, the write memory function writes a number of words to the AT49LV1025. The read memory function automatically increments the address after each read cycle and the write memory function increments the value of the data word it is writing after each write cycle.

The idea of this little demo pro-

gram is to show you how the erase functions work for the Boot Block and Main Memory while certifying that our basic AT49LV1025 FLASH read and write functions perform as advertised. Hopefully, you should be familiar enough with the AT49LV1025 firmware to associate what you see in Figure 3 with the AT49LV1025 code in Listing 1. **NV**

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A Review on the Hexcrawler HDATS

Building a Crustcrawler robot is like owning a luxury automobile. Everything about a luxury automobile is about being “a cut above the rest.” That is what a Crustcrawler is all about. It is a robot building experience. Every step of the way was sublime, every nuance of the build was exquisite. If everything I did went as flawlessly, I would be the king of the world.

Some time ago, I was fortunate enough to build one of their “2 x 6” Hexcrawlers. I found that experience to be wonderful, but my time spent on the Hexcrawler HDATS was blissful. The thing practically built itself.

I was amazed when I opened up the box to find how much stuff was in there. Dozens of stamped,

bent, brushed, and anodized parts, hundreds of screws, washers and nuts, all divided into neat little logical bags, all labeled and ready to consume, all waiting for their Hitec HS-645MG servos to bring them to life. There was even an ample supply of extra parts, in their own little bags, labeled to indicate they were spare.

The details really become apparent when you notice that the aluminum pieces are brushed along their long axis. One piece by itself is nice, but the whole beast built up takes on a magnificent sheen. Screws are a mixture of black oxide and shiny zinc plated, all matched up nicely for aesthetics. Another nice detail is all the pre-made mounting slots for mounting your own hardware. This makes accessorizing your Hexcrawler a breeze.

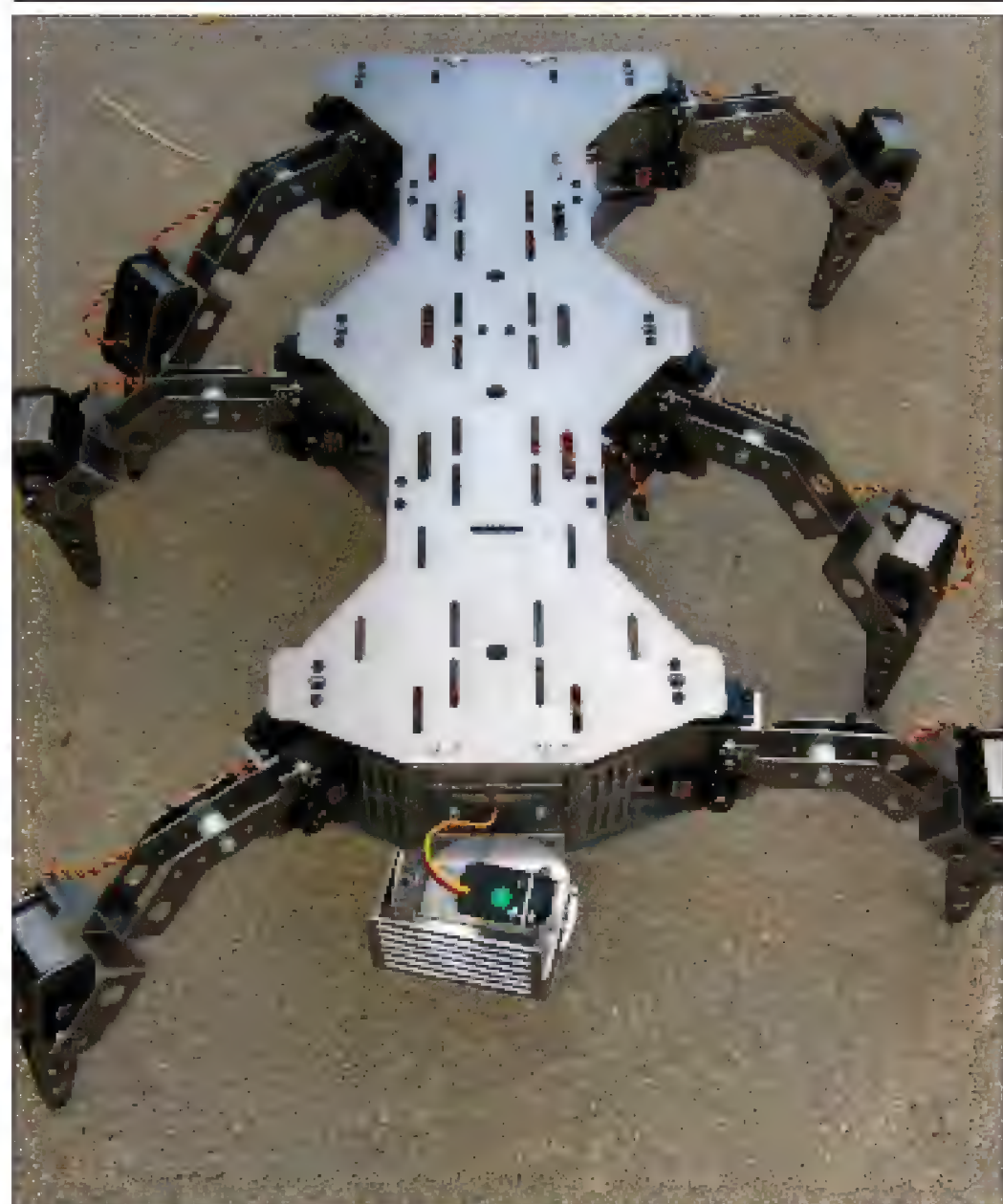
Another neat thing about it is the four different mounting points for the pivot of the knee. While it adds a bit of complexity for my inverse kinematics code, it allows you to trade between torque and travel. More power-

ful servos can use less torque advantage, and really move, or they can be set to more torque for better cargo capacity.

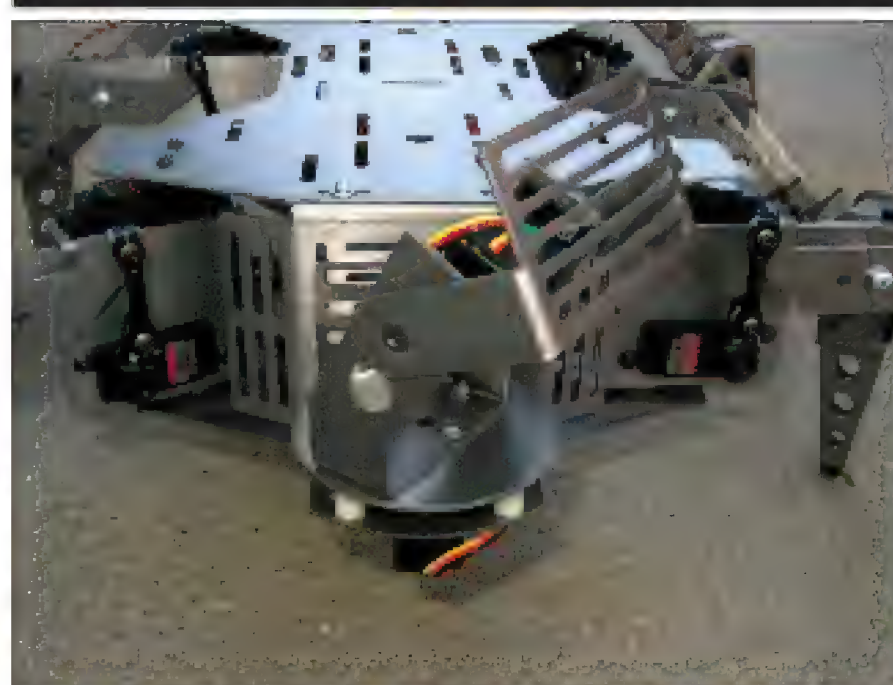
One thing that surprised me is how large this thing is. I mean it is like bigger than a badger. At something like 20” x 20” x 6”, this thing is really massive. With the heavy duty, 107 oz-in servos, and the fulcrums for the legs set at maximum torque advantage, I may not have enough stuff to put on it. I do know that my little IsoPods and ServoPods will be lost on this thing. I guess I will be accessorizing it with a lot of gear. Here is a rundown of what I am considering:

- Poloyquest LiPoly batteries from www.LightflightRC.com with battery monitor
- CMUcam2 from www.Seattlerobotics.com
- Lassen GPS module from www.Sparkfun.com
- 2.4 GHz wireless link from www.Sparkfun.com

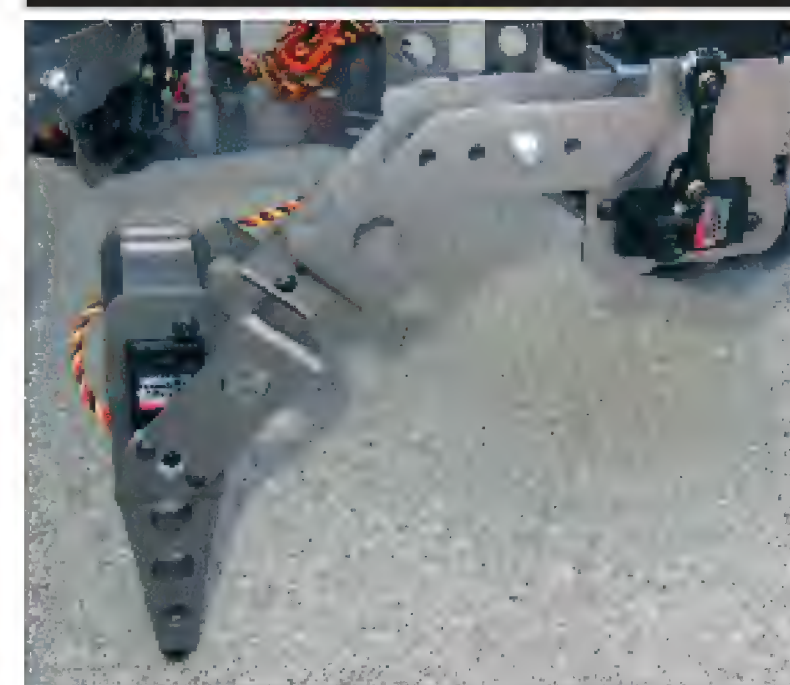
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Personal Robotics



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- Sharp distance ranging sensors
- CUlstack force sensors for the feet, see www.CUlstack.com
- TAOS color sensors from www.Parallax.com
- ServoPod for the brains from www.newmicros.com
- Gambboy Advance as a graphical display
- S3 Pan/Tilt system from www.CrustCrawler.com

With all that empty space between components, maybe this is the time to play with distributed processing and some sort of bus architecture, one computer for each leg, and one for the head. Maybe I need to find a rider to control it, maybe wire up a lab specimen that won't offend PETA like a giant Madagascar hissing cockroach like what Garnet Hertz did (www.conceptlab.com/control/) or maybe my pet snail. Whatever I can dream up, I know the thing will handle the mass.

The build was really straightforward, though I highly recommend looking

over the manual first, then proceeding to build. I managed to build mine up in about six hours, with only a Philips screwdriver, 3/32 Allen wrench, needle-nose pliers, flush cut diagonal cutters, 1/8" drill, and some tweezers.

There were no errors in the manual, though a couple of times I had to redo things, mostly due to my haste in building it. At times I wish the manual were a bit clearer, but when I approach something like this, I attack it in the most hurried of ways.

Overall, I couldn't be more pleased with the Hexcrawler HDATS. All the extra hardware was an unnecessary blessing. All the pieces fit together perfectly. With a minimal effort, everything came together flawlessly. This product gets a solid A+ rating from me. **NV**



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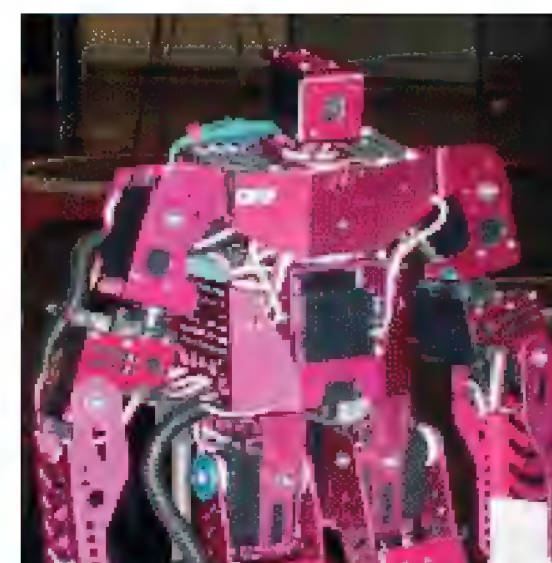
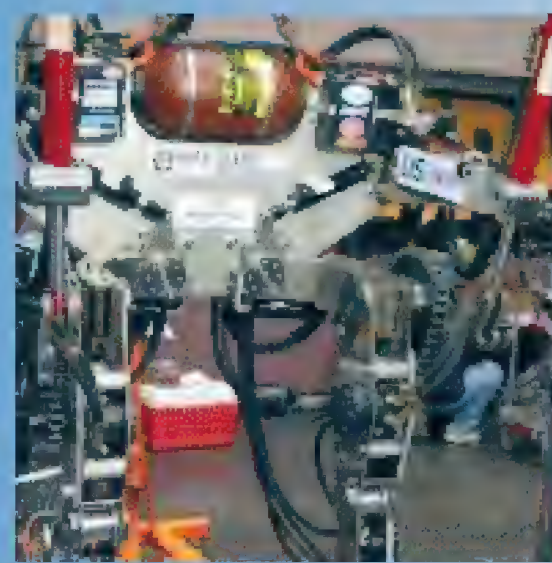
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In The Trenches

Recognizing and Encouraging Good Ideas

Engineers and engineering managers are always at the leading edge of technology. New ideas are potentially very valuable.

But, how do you know if a new idea is a good idea? What do you do when someone comes to you with a new idea? And, of course, how do you cultivate good ideas?

Why it's Hard

Recognizing a good idea is not as common as it should be. In fact, it's often a very difficult thing to do. There are several reasons. The first is that new ideas are — by necessity — unconventional. If the idea followed convention, it wouldn't be new. People like the status quo. So, anything that changes that, makes them uneasy. Engineers are people, too. (Although there are some who will disagree.) So, it's first nature to push the new idea aside. Clearly, that's just as wrong as vigorously pursuing every new idea that comes your way. Thus, the first thing to do when someone comes to you with a new idea is to listen and evaluate objectively.

Of course, this is work and it takes time. If Bob comes into your office five minutes before you have to go to a meeting and says "I've got this great idea." Don't say, "You've got five minutes." Instead schedule 30 to 60 minutes (perhaps lunch) so you can actually listen to what he has to say.

If Bob says, "It'll only take five minutes," it's probably not a good idea, or a well thought-out one. Good ideas take effort to make

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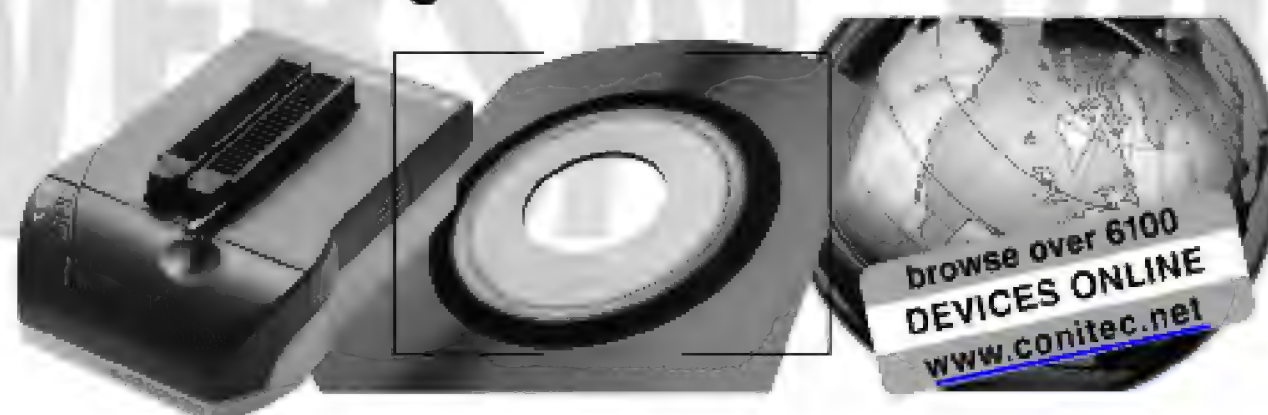
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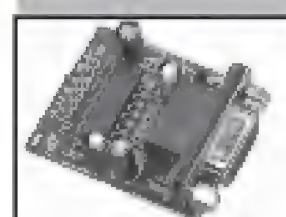
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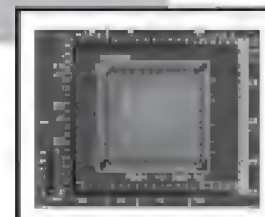
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them good. While the kernel of an idea may take only five minutes to explain, that in itself isn't necessarily good. The kernel's application and potential benefits and risks will take more than five minutes to discuss. If Bob can't address these points, he hasn't done his homework.

New ideas involve new risks. Again, it's human nature to accept familiar risks and avoid unfamiliar ones. Another word for this is experience. We all know how valuable experience is. If you're a hardware engineer, you'll probably design an analog audio filter because of your experience. If you're a software engineer, your first choice will be a digital filter. It's rare that it will be reversed unless there is significant pressure applied (for whatever reason). It's human nature to overestimate new risks while underestimating old risks.

Finally, new ideas require new words and thoughts. It's often very difficult to verbalize these things simply. Worse, Bob may not have good verbal communication skills.

So, getting his idea across may take considerable effort from both parties. Sometimes, it is simply impossible to bridge that verbal chasm.

What Makes an Idea Good

Fundamentally, a good idea solves a problem. Sometimes the problem is obvious. Sometimes people don't even know that there is a problem.

For example, what problem did wireless transmission (or "radio") solve? At the time, many people felt that the telegraph was just fine. Ideas that solve problems that are not obvious are the hardest to

evaluate.

Of course, there are many types of "solutions." They can range from physical to financial to social. Good ideas have benefits that outweigh the costs. "Well, duh! That's pretty obvious," you say. The not-so-obvious problem is that quantifying the benefits and costs is not an easy thing to do.

This is especially true for novel ideas. The costs of developing "radio" were significant. The benefits, at the time, were not very clear. Radio range was much less than the telegraph and radio was much more complicated. Additionally, everyone could receive radio with the proper equipment. So, any message sent by radio was not very private. Not like the telegraph at all.

In the long run, new ideas will generally be cost-effective. That is why there is so much academic and industrial funding for theoretical

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research.

However, when someone comes to you about their idea, you don't have the luxury of waiting years or decades to recover the developmental costs. You will have to examine the idea from the short term point-of-view.

Be Formal

I have found that a formal evaluation procedure of a new idea is very useful. Formal doesn't have to be intimidating. In fact, a properly designed formal evaluation can be much less stressful than an informal one. But this means up-front work for both parties.

First, you should publish a checklist of those topics that the new idea should address. For example: "What are the benefits of the idea? Be as specific as you can." What are the risks? How is the idea to be implemented? Are there similar ideas in use now? How long/how much will it take to develop? You might also place limits. It can't cost more than a certain amount to develop. It must be profitable within a specified period of time.

These topics are important to Bob because he probably hasn't thought about them. He's been focused on his great new idea, not on business. By having him examine his idea from a business perspective, he can get a better understanding of what is important to the company.

Additionally, he will have the time to think about and develop discussion points that are company-oriented. He'll know what to expect in the meeting. That's helpful to him. It's always easier to go into a meeting knowing what questions will be asked.

Have Bob write a paper to present and discuss at the evaluation meeting. This does several things. It forces Bob to organize his thoughts. It's often the case that someone thinks they understand something until they start writing it down. Only

then do the gaps in logic and improper reasoning become visible.

Additionally, new ideas are not born fully formed. They can be just a shadow or outline of a practical concept. They need to grow and evolve. Writing about an idea puts substance into the shadow. Bob has to think about his writing, as well as his idea. It also shows that you are

taking Bob seriously.

Allow Bob to bring an associate or two. This provides two benefits. The first is that Bob will feel more comfortable with a friend. It will be easier and less stressful. The second point is that the friend may be able to help Bob on difficult points. Having a different person explain a concept can be very useful.

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After all, the point of the meeting is to understand what Bob is proposing.

A formal evaluation (in writing) should be the result of this meeting. Hopefully, the evaluation should be presented to Bob within a week or so. It doesn't have to be long, perhaps a page or so. If the idea is accepted, you will want to lay out a preliminary

budget and schedule in the evaluation. There may be special requirements or situations that need to be defined, as well as limitations and expectations. Clearly, there will be ongoing meetings and progress reports. But, this is great news for Bob.

If the evaluation is negative, it is critically important to be specific.

Precisely, why isn't the proposal a good idea? This should be spelled out. Perhaps it costs too much or will take too long to develop. Maybe, it's unethical or violates copyright or patent laws. Possibly you disagree with Bob's assessment of profitability. Whatever the reason, state it. It is certainly nice to couch it in pleasant terms, but tell the truth.

There are two fundamental reasons for this. The first is your own credibility. If you just blow-off the idea, you will not get many more. Subordinates will think that the evaluation is just some arbitrary bureaucratic procedure. The second point is that your objection(s) may be answerable. Bob might be able to overcome the weakness in his idea if he is given the direction and opportunity to do so.

Of course, this means that you must be truly willing to reconsider the idea if the stated objections have been overcome. If an idea is too far removed from the company's core interests and will never be acceptable, this should be stated as well.

Note that I have not discussed any technical aspects of the idea. This is because it is assumed that Bob — an engineer — will have a good grasp of what is possible and practical. Most ideas, especially those created by engineers, are technically feasible. Although, sometimes a person's imagination exceeds his capabilities.

Corporate Fears

It always seems to be the case that upper-management and executives fear all the time "wasted" on evaluating ideas. They're afraid that Bob will re-submit his idea again and again. They're afraid that "important" work will be delayed. These are silly fears.

First, an idea is a very personal thing. Few people enjoy having their visions rejected. It's very unlikely that anyone will choose to endure that

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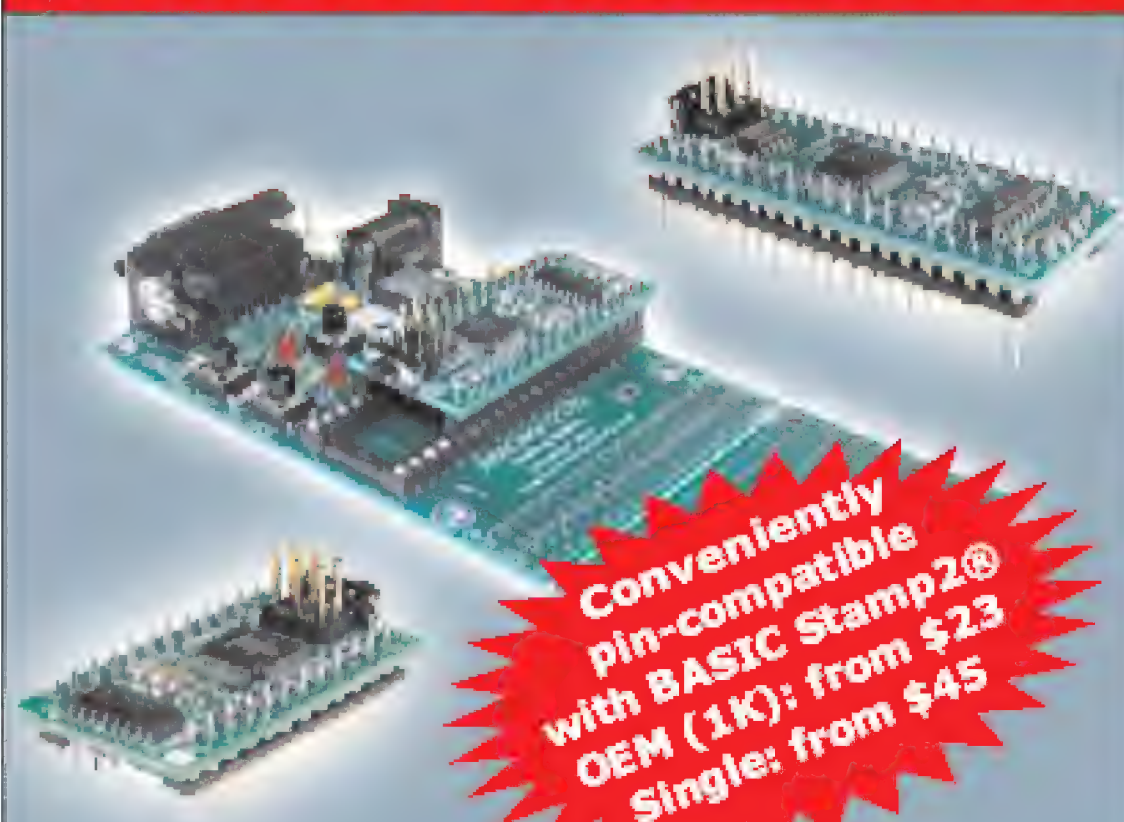
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over and over again. This is especially true if the evaluation was honest to begin with.

Secondly, it's important to cultivate good ideas. The company was founded on someone's good idea to begin with. Simply, good ideas are profitable and bad ones aren't. Every company must grow and that can only be done with profitable, good ideas.

Then there is the corporate mindset. This is the notion that the people who make the decisions must be smarter than those who just "work." In my experience, this egocentric point-of-view is surprisingly common (unfortunately). What's more, these people are not aware of how counter-productive this is and are usually unwilling to consider anything else. "The important people have all the good ideas."

For some reason, these people cannot see that an employee, on his own time, has created an idea that he thinks will make the company (and himself, of course) lots of money. What's more, he is willing to share this with the company. All Bob is asking for is a fair hearing about his idea. Not encouraging this behavior is simply a silly thing to do.

Rewards for Ideas

Suppose Bob's new idea provides a \$1,000,000.00 yearly increase in product sales with a net profit of \$100,000.00 to the company. The company gives Bob a \$10,000.00 bonus. Once.

Do you think Bob is happy knowing that the company owners get \$90,000.00 this year and \$100,000.00 every year thereafter while he gets a one-time bonus of \$10,000.00? Would you be happy? Do you think Bob will ever provide another idea to the company? Or will Bob take a job at a different company where his ideas are worth more?

Management sometimes seems to think that people are stupid.

AUGUST 2005

They think that they are giving away \$10,000.00. They fail to realize that it is Bob who is really giving them \$100,000.00 every year. So, instead of rewarding Bob with a meaningful reward, they make Bob feel that he is being taken advantage of. And, of course, he is correct.

A proper reward would be some-

thing like 50% of the savings for the first year and 10% thereafter (or for some specified number of years). This will encourage Bob and others like him to provide the company with profit-making ideas. It's critically important to realize that Bob is the source of the \$100,000.00 yearly profit. He is the one who decided to give the company his idea. It's up

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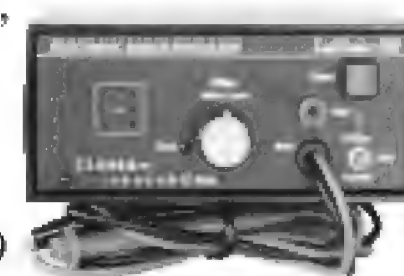
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In The Trenches

to management to ensure that he will repeat his behavior the next time.

It also makes sense to reward people for all new ideas. Even for those that are not accepted. This is because Bob put forth a significant effort in creating his idea and writing it down (for the evaluation). Additionally, he places himself at some risk of embarrassment and/or ridicule.

Obviously, the evaluation should always be handled professionally. But, Bob's idea is a very personal thing and he is vulnerable. He knows that new ideas are often laughed at.

So, even if the idea can never be used by the company, give him \$100.00 for his effort and courage. He will appreciate it and will be all the more willing to submit more ideas. And, let's be practical. Where else can you get new ideas for \$100.00 each? eBay doesn't auction them.

Note. Again, some executives fear that Bob will take advantage of the situation by simply submitting idea after idea. This is not a reasonable fear. If your checklist is properly designed, he can't repeat the idea. If the evaluation is accurate, he will be forced to do considerable work to make the idea suitable for re-submission.

Naturally, Bob should not use company time to work on his ideas. So, the \$100.00 is a reward for work in excess of his regular job duties. Again, this is a great bargain for the company.

The Suggestion Box

The suggestion box is arguably the worst idea for collecting good ideas ever employed.

At its best, it's just a morale boost for the employees. The box gets suggestions like: "How about putting a candy machine in the break room?" Or, "Let's go to a four-day work week."

Basically, it's just a feedback mechanism to management. If the

feedback isn't acted upon, then the box is perceived as another failed management tool that illustrates how out of touch management really is.

You will not find suggestions like: "Improving throughput by applying ergonomics to the production process." But these are exactly the ideas that the company needs. These are the ideas that can save the company huge amounts of money. How much profit will a candy machine make?

Recognizing Good Ideas (Peer-to-Peer)

When a co-worker comes to you about an idea, you can't expect him to put it in writing. Rather, it should be a sit-down discussion. Be sure you have a block of time (usually an hour is adequate.) Sometimes lunch is a good idea. Always remember that ideas are fragile, personal things.

Even if it's a perpetual motion machine, take it seriously. This person has come to you for your comments, so be gracious. Peer-to-peer discussions will usually concentrate on the technical aspects that both people are familiar and comfortable with.

A good idea is well thought-out with attention to detail. So, listen carefully. If something doesn't make sense, ask for clarification. (Say, "I don't understand that part." Not, "That part doesn't make sense.") If the explanation does clarify the point, that's good. If not, it's bad because either the point is not well-understood or it's poorly verbalized.

Are the implications (also called secondary effects) understood? Suppose the design calls for the use of mercury. That's a heavy metal and may soon be banned in Europe and perhaps in the USA. Has he considered this? If not, is there a different approach that can work?

What specific problem does it solve? Some ideas are very intriguing, but have little application. Ideas

that have the potential for wide application are valuable. Is the idea for new technology, saving money, or social application? There are many different things to consider. Creating a pill that makes everyone the same size is a new technology. It saves money by allowing manufacturers to make only one size of clothing. And it clearly has a social application. But, what problem does it solve? It suggests that the problem is that people are of different sizes.

On the other hand, what about creating a cloth that can be stretched and then easily size-fixed-to-fit at the store. This does solve the problems of inventory and manufacturing multiple sizes of clothing. Changing the clothing to fit the person seems like a much better solution than changing the person to fit the clothes.

Recognizing Good Ideas (Worker to Boss)

As was noted before, a manager looks at broader, more non-technical aspects of the idea. Generally, the outlook is pragmatic. If the idea helps the business, it's good. Otherwise it's bad.

It's important for the worker to understand this. If the company makes CRTs, a cure for AIDS (a vastly important idea) will generate little interest. Not because the people don't think it's a good idea. More simply, the company doesn't have the mechanisms in place to exploit it. A good idea from the manager's perspective is one that fits the company.

Naturally, the idea must be understood well enough by the manager to evaluate. And, let's assume that this is the case.

Oftentimes, the source of the idea can help determine if it's a good one. If Bob, a good worker with lots of experience, says that he can improve production by building special test fixtures, the idea will be

readily accepted. However, if this is Bob's first job out of high school and he's only been working for two weeks, it will be much more difficult to accept. It doesn't mean that the idea is bad. It's just that the new hire has had no time to develop credibility.

Recognizing Good Ideas (Non-technical to Technical)

I often have non-technical clients who want me to develop their idea into a product. Here, the criteria for being good are more general. Is the idea feasible? Is the idea practical? Is the idea potentially profitable?

Obviously, it's unrealistic for a non-technical person to address the technical aspects of his idea. It becomes the evaluator's responsibility to consider these.

This can turn into a difficult situation if the technical person isn't being compensated for the evaluation. This is because the technical person can easily become a "co-inventor" of the idea. If Bob comes to you with a nub of an idea and you show him how to build it, you have

helped to turn the idea into a product. What do you do if Bob then goes to someone else to build and market the idea and makes millions of dollars?

Conversely, suppose Bob takes your input and makes a faulty product. He gets sued. And so do you, because you were the brains behind the design.

Both of these scenarios are rare, but they are possible. The important thing to remember is that you are likely to become "partners" with Bob in some fashion. The question then becomes: Is it a good idea to work with Bob? Rather than: Does Bob have a good idea?

Conclusion

Ideas, like beauty, are in the eye of the beholder. Different people will evaluate the same idea in different ways and come to different conclusions.

Fostering good ideas requires a true effort by management. And, because businesses must grow and evolve to stay competitive in today's business environment, good ideas are the life-blood of the company. **NV**

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TETSUJIN 2005

Tetsujin 2005 — originally scheduled for October 6-9 at RoboNexus — has been postponed. The registration deadline passed on June 13th, and there were not enough entries to hold the competition on the scheduled date.

We plan to reschedule the event sometime after the first of the year at a different venue. Individuals and teams interested in competing should drop us an email to let us know, so we can plan to go ahead and set a new date. The entry deadline will remain open for now. Don't send money or the entry form yet, just email to let us know you are interested in competing and we'll keep you posted on what to do next and when to do it.

Hey, look on the bright side, not only do you *STILL* have time to enter, you have even *MORE* time to design and build your exosuit! So, there's no excuse now *NOT* to compete! This is a hard competition and certainly one worth participating in. If it were easy, everyone would be doing it. This is your chance to stand apart from the crowd and flex your engineering and bot-building

muscles. So, hook up with your friends, fellow engineers, classmates, geeksquad, gearheads, whoever, and form a team. No need to go it alone!

If you haven't already done so, check out the new rule set and event changes and start scribbling out your preliminary design. There's no time to lose! **Send an email to tetsujin@servomagazine.com** with your name and email address and we'll make sure you get all the latest info and news.



CHALLENGE 1:

Weightlifting. Ascend stairs in your suit to the lifting platform and lift a load of from 100 to 1,000 lbs* from a squatting position to a height of at least 24 inches*, return the load to the ground in a controlled manner, and descend the stairs. Stair-climbing may be unpowered. The winner is the competitor who lifts the most weight.

CHALLENGE 2:

Dexterity. Stack nine concrete cylinders weighing about 70 pounds each in a 4-3-2 vertical arrangement, but don't knock them over as the pyramid grows! The winner is the competitor who arranges the cylinders in the shortest time.

CHALLENGE 3:

Walking Race. Walk the 100 foot* long U-shaped challenge course, stepping over a small obstacle at the half-way point. The shortest time wins, with a time bonus being granted based on any auxillary load carried. Walking must be powered.



The current rule set is available online at
www.servomagazine.com

Questions can be directed to
tetsujin@servomagazine.com

**Don't wait, sign up for one, two,
or all three challenges today!**

*Specifics of the competition are in a tentative state and may be subject to change.

Tech Forum

QUESTIONS

I do telephone interviews (and have permission of the other party to record them). I need a phone patch circuit for a cell phone to get audio out at standard audio mixer levels that I can record via a laptop/computer sound card or cassette. Since the audio transmit and receive are separate with cell phones, the signals do not need to be mixed. I can run them separately to the right and left channels and mix them later.

The phone patch must plug into a Motorola T-2260 cell phone headset jack (standard 2.5-mm, three-conductor phone jack). The three

conductors are transmit, receive, and common ground. I believe that phantom power is supplied to the transmit (mic), as well.

I've already tried making a simple circuit that de-coupled the DC with 0.1mF and then 0.01mF caps in series with the signal lines, but I had the problem of the mic audio cutting out after a few seconds. I even tried an audio transformer isolation to stop ground loops. I'm thinking that there is RF coming in over the lines. Any ideas?

#08051

Clyde
via Internet

How does the LNB on a satellite receiver dish work? I know that

LNB stands for "Low Noise Block" converter.

#08052

Sam Graumann
Canon City, CO

I need to assemble a device which will record time-of-day in 24-hour format for events, as follows: a person sees an event, and pushes a button; he sees another event, and pushes another (or the same?) button. Later, he can retrieve the event times (capability for up to five events will be needed) and reset the device for use next time. It would be used in a 12-volt vehicle.

This could be as simple as tying together panel-mount clock modules that can be synced when setting the time. I know this can be done with a PIC and LCD display, but I know very little about them, and haven't been able to get off the ground with that approach.

#08053

Doug Johnson
Kingsford, MI

ANSWERS

[#06052 - June 2005]

I'm using a PIC microcontroller to send data serially to my PC as sort of a data logger. I've been using hyperterminal to capture the info, but I need a time stamp on each incoming line to tell what time the data was taken. The time stamp should be system or actual time. I've tried using a serial port monitor program by Retisoft, but it uses its own stopwatch-style stamp, which doesn't mean a whole lot to me.

The easiest way to do this is to get a terminal emulator that supports scripts, such as Procomm Plus or NetTerm. You can then write a script that will detect an incoming pattern such as carriage return, linefeed, or other unique character (~) and insert the host computer's date and time into the data stream. You can even write automatic file swapping scripts that will create new capture files hourly, daily, or monthly.

The alternative would be to write

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indicate to that effect.

- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

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- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

a simple datalogger program using C or even Basic to perform the data capture and date-time stamping.

I can help you with either option if you need assistance.

Daryl Rictor
circuithelp@yahoo.com

[#06055 - June 2005]

I have several refrigeration controllers for store produce coolers that I cannot find any programming documentation on and I'm hoping that someone can help.

I have a Cool/Delay Heat controller with dual temp probes. It's made by McLean Midwest. It has the part name Zero McLean on the wiring label. The part number is 10-1106-33 Rev: 0.

I would appreciate any information available – especially programming info.

A quick search with Google

shows that [Primeparts.net](http://www.primeparts.net) is now handling many McLean Midwest products and parts at www.primeparts.net/Products/mclean.shtml.

I don't see the part in question on their site, but maybe they have information on it. They can be contacted at the web address, or by email at websales@primeparts.net or by phone at (317) 257-6811.

Carl Smith
Dakota Dunes, SD

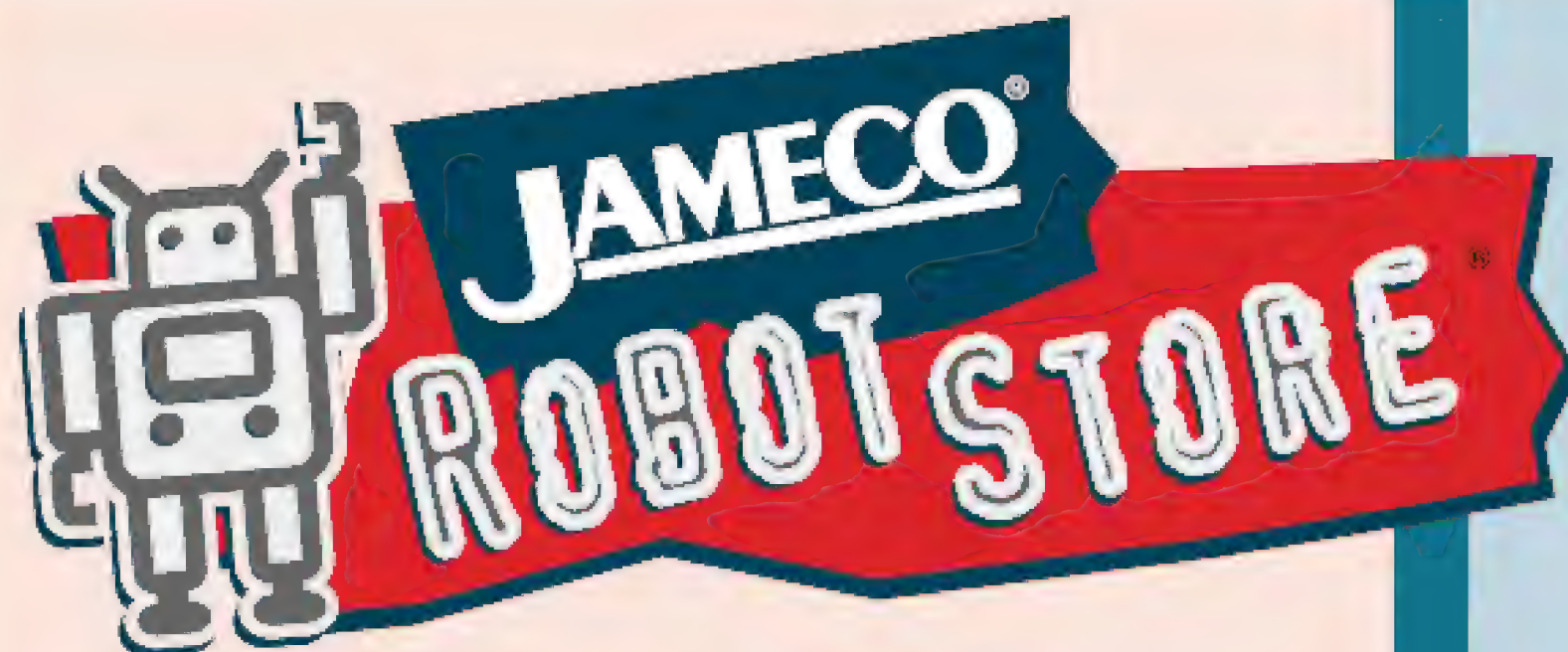
[#07052 - July 2005]

I want to build a receiver circuit for a TV remote control. With the number of cheap "Universal" remote controls that are available, I'm hoping to be able to use one of these to control some of my electronics projects, without the need to construct the remote control itself. I'd think other experimenters could utilize such a receiver to add remote control capability to their robotic and other

electronic projects. I suppose I could try to salvage this circuit from an old TV or VCR, but since I'm not interested in having a tuner for TV signals, I was hoping for a simpler circuit. I'm also looking for a good book on how to troubleshoot these circuits in various TV and VCR applications.

#1 IR remote controls use a pulsed signal that modulates a 38 kHz carrier. The detection circuit for those signals is very easy. You can purchase photodetectors that contain a filter at 38 kHz, so you are basically making them immune to other IR signals that are present in the environment.

For example, the Panasonic PNA4602 is one of these units that I have experimented with. It can be easily purchased at solarbotics.com at a cost of \$1.50 per unit when I just checked it. The documentation for this unit can be found at: <http://>



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downloads.solarbotics.com/PDF/PNA4602_datasheet.pdf

Other IR receivers can be found at Electronics Goldmine www.goldmine-elec-products.com

You should also consult the January 2005 issue of SERVO Magazine (www.servomagazine.com) that contains an excellent article on decoding these signals, including a schematic.

Finally, the Parallax website has a very good "Stamp Weekend Application Kit" on infrared emitting diodes and 40 kHz infrared detectors that can be downloaded for free at www.parallax.com/dl/docs/prod/compshop/irledndet.pdf

**Albert Lozano
Edwardsville, PA**

#2 I have had great success using Athena class microcontrollers connected to a Vishay IR module. These microcontrollers have IR functions built in to read and send either Sony standard codes or raw data codes. Application notes can be found at www.kronosrobotics.com/application.shtml. This page contains a few different examples of transmitters and receivers for different class microcontrollers, as well as a list of common Sony codes.

**Christopher Coyle
Unionville CT**

#3 The Innotech Systems IC1003 can decode most IR remote controls and provides a three-character ASCII code via a 9600 baud RS-232 signal. Here is a link to the Innotech website: www.innotechsystems.com/ic1003.htm

Decoding an IR signal is relatively simple, and it can be done using a common microcontroller, such as a PIC or AVR.

Here is a link to a PIC-based project: www.ida.net/users/oe1k/uirt/uirt.htm Here is a link to an AVR-based project: www.unchanged.net/Electronics/RECS80/

**Daryl Rictor
via the Internet**

[#07054 - July 2005]

I have a number of IF transformers with no color-coded leads, and the primary and secondary have similar DC resistance. How can you determine the primary from the secondary, specifically the plate (collector) from the grid (base) leads?

The old IF transformers were designed to provide selectivity, not gain, so it probably does not matter which way you hook them up. If you have a signal generator and scope, feed a signal into one side and look at the output. The side producing gain (if any) will be the grid side. The frequency will either be 455 kHz or 10.7 mHz, although 262 kHz was also used.

**Russell Kincaid
Milford, NH**

[#07055 - July 2005]

I'm using motor controllers with LMD18200 amplifiers in a robotics project, and the amplifiers literally blow up if the motor power is reversed! I'd like to find a simple way to protect from reverse polarity, but without an inline diode or rectifier because of the voltage drop associated with diodes, especially at higher currents when the motor really needs all the voltage it can get.

It would be nice to avoid old-fashioned fuses, as well.

A series MOSFET will be a low loss switch that will turn off when the voltage is reversed. Use a logic level device like Mouser part number 512-FQP20N06L (99 cents). Connect the gate to the positive input, the drain to the negative terminal of the motor controller, and the source to the negative of the battery. You won't need a heatsink in this application. The gate is rated 20 volts max, so if you are operating at 24 volts, a resistor and zener at the gate would be good insurance.

**Russell Kincaid
Milford, NH**

AUGUST 2005

Abacom Technologies35	Conitec DataSystems85	Halted Specialties Co.41	Maxstream49	RABBIT Semiconductor.....3
ActiveWire, Inc.92	CrustCrawler.....83	Hobby Engineering30	microEngineering Labs.....54	Ramsey Electronics, Inc. ...24-25
Adv. Microcomp. Systems71	Cunard Associates92	Industrial Ventures75	Micromint87	RCG Research55
AI Applications, Inc.9	Diskology92	Information Unlimited13	Mouser Electronics71	RE Smith33
All Electronics Corp.56	Diverse Electronic Services.....92	Integrated Ideas & Tech., Inc. .65	Multilabs32, 92	Robotic Trends84
Atlantic Int'l Institute, Inc.39	Earth Computer Technologies .35	Jameco95	Net Media2	Scott Edwards Electronics, Inc. .39
Atomic Time.....77	eBay7	Jaycar Electronics17	Parallax, Inc.Back Cover	Solutions Cubed86
AWC85	Electronic Design Specialists .89	LabJack66	PCB Fab Express92	Surplus Sales of Nebraska47
BalBots.com49	EMAC, Inc.29	Lemos International Co., Inc. .21	PCB Pool29	Syspec, Inc.89
Bellin Dynamic Systems, Inc. .92	ExpressPCB31	Link Instruments5	Pico Technology Ltd. UK.....79	Technological Arts88
Budget Robotics66	EZ PCB21	Linx Technologies81	PolarisUSA Video, Inc.11	Tetsujin 200593
C & S Sales, Inc.61	Front Panel Express LLC91	Lynxmotion, Inc.37	Pulsar, Inc.92	Trace Systems, Inc.88
Circuit Specialists, Inc.98-99	Graymark.....59	Matco, Inc.92	QKITS.....92	XGameStation92
Command Productions15	GreenChip53		R4Systems, Inc.23	Zagros Robotics92

AMATEUR RADIO & TV

Atomic Time77
PolarisUSA Video, Inc.11
Ramsey Electronics, Inc.24-25
Surplus Sales of Nebraska47

BATTERIES/CHARGERS

Cunard Associates92

BUSINESS OPPORTUNITIES

EZ PCB21

BUYING ELECTRONIC SURPLUS

Diverse Electronic Services92
Earth Computer Technologies35
GreenChip53
Jaycar Electronics17

CCD CAMERAS/VIDEO

Circuit Specialists, Inc.98-99
Matco, Inc.92
PCB Fab Express92
PolarisUSA Video, Inc.11
Ramsey Electronics, Inc.24-25

CIRCUIT BOARDS

Advanced Microcomputer Systems, Inc.71
Cunard Associates92
ExpressPCB31
EZ PCB21
Maxstream49
Micromint87
PCB Fab Express92
PCB Pool29
Pulsar, Inc.92
R4Systems, Inc.23

COMPONENTS

Bellin Dynamic Systems, Inc.92
Front Panel Express LLC91
Jameco95
Lemos International Co., Inc. .21
Linx Technologies81
Maxstream49
Micromint87
Pulsar, Inc.92
Solutions Cubed86

COMPUTER

Hardware
ActiveWire, Inc.92
Diskology92
Earth Computer Technologies35
Halted Specialties Co.41
PCB Fab Express92
Surplus Sales of Nebraska.....47

Microcontrollers / I/O Boards
Abacom Technologies.....35
AI Applications, Inc.9
AWC85
Conitec DataSystems.....85
EMAC, Inc.29
microEngineering Labs54
Micromint87
Multilabs32, 92

Net Media2
Parallax, Inc.Back Cover
R4Systems, Inc.23
Scott Edwards Electronics, Inc.39
Technological Arts88
Trace Systems, Inc.88
XGameStation92

Software
Advanced Microcomputer Systems, Inc.71

DESIGN/ENGINEERING/REPAIR SERVICES

ExpressPCB31
EZ PCB21
Front Panel Express LLC91
PCB Pool29
Pulsar, Inc.92
R4Systems, Inc.23
Trace Systems, Inc.88
Solutions Cubed86

EDUCATION

AI Applications, Inc.9
Atlantic Int'l Institute, Inc.39
BalBots.com49
Command Productions15
EMAC, Inc.29
Graymark59
Hobby Engineering30
RCG Research55
Syspec, Inc.89
XGameStation92

ENCLOSURES

Integrated Ideas & Technologies, Inc.65
--

EVENTS

Robotic Trends84
Tetsujin 200593

KITS & PLANS

AI Applications, Inc.9
C & S Sales, Inc.61
Earth Computer Technologies35
EMAC, Inc.29
Graymark59
Hobby Engineering30
Industrial Ventures75
Information Unlimited13
Jaycar Electronics17
QKITS92
RABBIT Semiconductor3
Ramsey Electronics, Inc.24-25
Scott Edwards Electronics, Inc.39
XGameStation92

LASERS

Information Unlimited13

MISC./ELECTRONICS FOR SALE

RE Smith33

MISC./SURPLUS

All Electronics Corp.56
Front Panel Express LLC91
GreenChip53
Halted Specialties Co.41

Surplus Sales of Nebraska47

MOTORS

Jameco95

PROGRAMMERS

Conitec DataSystems.....85
microEngineering Labs54

PUBLICATIONS

Mouser Electronics.....71

RF TRANSMITTERS/RECEIVERS

Abacom Technologies35
Linx Technologies81
Matco, Inc.92

ROBOTICS

BalBots.com49
Budget Robotics66
CrustCrawler83
Hobby Engineering30
Jameco95
LabJack66
Lemos International Co., Inc.21
Lynxmotion, Inc.37
Net Media2
Solutions Cubed86
Zagros Robotics92

SATELLITE

Lemos International Co., Inc.21

SECURITY

Information Unlimited13
Linx Technologies81
Matco, Inc.92
PolarisUSA Video, Inc.11

TEST EQUIPMENT

Bellin Dynamic Systems, Inc.92
C & S Sales, Inc.61
Circuit Specialists, Inc.98-99
Conitec DataSystems.....85
eBay7
Electronic Design Specialists89
Jaycar Electronics17
LabJack66
Link Instruments5
Pico Technology Ltd. UK.....79
Trace Systems, Inc.88
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Add On Board for CX101 & CX102 Series (CX-ADD ON BOARD).....\$4.50

LCD Panel Meters:

	Selectable 5V/9V, AC/DC version (PM-128E)....	\$12.25
	9V Independent Ground (PM-138).....	\$10.90
	9V Independent Ground (PM-188BL).....	\$12.50
	9V Independent Ground (PM-228).....	\$12.50
	4-1/2 Digit 9V Independent Ground (PM-328)....	\$19.88
	9V Independent Ground (PM-438).....	\$10.95
	Miniature 9V Independent Ground (CX101A)....	\$13.50
	Miniature 5V Common Ground (CX101B).....	\$13.50
	Miniature 5V Common Ground (CX101BG).....	\$13.95

www.CircuitSpecialists.com

Circuit Specialists Soldering Station w/Ceramic Element & Seperate Solder Stand

- Ceramic heating element for more accurate temp control
- Temp control knob in F(392° to 896°) & C(200° to 489°)
- 3-prong grounded power cord/static safe tip
- Seperate heavy duty iron stand
- Replaceable iron/easy disconnect
- Extra tips etc. shown at web site

\$34.95!



Item# **CSI-STATION1** *Rapid Heat Up!*

Also Available w/Digital Display & MicroProcessor Controller

Item# **CSI-STATION2A**

\$49.95

Details at Web Site

> Soldering Equipment & Supplies > Soldering Stations

SMD Hot Tweezer
Adaptor Fits CSI Stations 1 & 2, and also CSI906

\$29.00

Item# **CSITWZ-STATION**

**In Business**

Circuit Specialists Inc.

Since 1971

**Bullet Style B/W Camera**

- Weather Proof
- Signal System: EIA
- Image Sensor: 1/3" SHARP CCD
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2



Item# **VC-305**

1-4: \$49.00 5+: \$46.00

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

High Capacity Nickel Metal Hydride Rechargeable Batteries

Item#		1+	10+	100+
AA2500MAH	"AA" cell 2500mAH	\$1.45	1.25	1.09
AAA850MAH	"AAA" cell 850mAH	\$0.99	0.65	0.51
C3500MAH	"C" cell 3500mAH	\$2.99	2.30	2.09
D11000MAH	"D" cell 11000mAH	\$6.95	5.55	4.39
9V220MAH	"9V" cell 220mAH	\$3.69	3.29	2.99

Details at Web Site

> Batteries & Accessories > NiMH Batteries

NEW!

13.8V DC Regulated Linear Power Supplies

Rugged power supplies that provide 13.8 Volts and substantial amounts of current! These are suitable for various applications including Automotive, Marine and Radio Equipment, along with High-Amp Stepper Motors and CNC (Computer Numeric Control) Machines. Choose from three models; CSI1862 with 6 Amps, CSI-1865 with a robust 20 Amps or CSI-1869 with a beefy 40 Amps at your disposal.

Item#	Price
CSI1862:	\$24.95
CSI-1865:	\$69.00
CSI-1869:	\$119.00

NEW!



Details at Web Site > Test Equipment > Power Supplies > DC Power Supplies

Triple Output Bench Power Supply

with Large LCD Displays

Output: 0-30VDC x 2 @ 3 AMPS
& 1ea. fixed output @ 5VDC@3A
Source Effect: $5 \times 10^{-4} = 2\text{mV}$
Load Effect: $5 \times 10^{-4} = 2\text{mV}$
Ripple Coefficient: <250uV
Stepped Current: 30mA +/- 1mA
Input Voltage: 110VAC

CSI3003X3/\$179.00
(qty 5+/\$169.00)

Details at Web Site

> Test Equipment > Power Supplies

Protek 100MHz Realtime Scope

2 Ch Dual Trace
6" Internal Grid
ALTMAG
ALTTRIG
TV Sync
5 Vertical Modes



Item# **6510**

Brand New
Not Refurbished!
Includes 2 scope probes

A \$975.00 Value!
100MHz only \$499.00
While Supplies Last!

Details at Web Site > Test Equipment > Oscilloscopes/Outstanding Prices

A Complete Electronics Lab

You supply the PC to complete a powerful test system which includes a two channel Digital Storage Oscilloscope, a 16 channel Logic Analyzer, an Arbitrary Waveform Generator, two Programmable Power Supplies and two Programmable Clock Generators.

Details at Web Site

Item# **ELAB-080**

> Test Equipment > Oscilloscopes/Outstanding Prices



\$495.00

Dual Output DC Bench Power Supplies

High stability digital read-out bench power supplies featuring constant voltage and current outputs. Short-circuit and current limiting protection is provided. SMT PC boards and a built-in cooling fan help ensure reliable performance and long life.

- Source Effect: $5 \times 10^{-4} = 2\text{mV}$
- Load Effect: $5 \times 10^{-4} = 2\text{mV}$
- Ripple Coefficient: <250uV
- Stepped Current: 30mA +/- 1mA

Both Models have a 1A/5VDC Fixed Output on the rear panel

CSI3003X-5: 0-30v/0-3amp/1-4..\$97.00/5+..\$93.00

CSI5003X-5: 0-50v/0-3amp/1-4..\$107.00/5+..\$103.00

Details at Web Site > Test Equipment > Power Supplies

As Low As \$93.00!



HOT ITEM!

Premier Repairing System w/Power Supply

Microprocessor controlled design that provides stability and precision of temperature and airflow settings during the rework process. A full digital display of temperature and power source make everything clear to the user while the unit provides vast flexibility at the rework station with the built-in power supply that provides 15V and 2A of power. Hot air soldering and adjustment of temperature are controlled by a micro chip and sensor thus giving tremendous accuracy and reliability.

Item# **CS1768****Only \$289.00!**

- Iron Output Voltage: 24V / 35W
- Temperature Range: 100-480°C / 212-896°F
- DC Power Supply: 15V / 2A

NEW!

Details at Web Site > Soldering Equipment & Supplies

2.9GHz RF Field Strength Analyzer

The **3290** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2900MHz. The 3290 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones, Cordless phones, paging systems, cable & Satellite TV as well as antenna installations. May also be used to locate hidden cameras using RF transmissions.

Item# **3290**

Details at Web Site > Test Equipment > RF Test Equipment

Fantastic Low Price: \$1899.00!

- WFM/NFM/AM/SSB modulated signals may be measured.
- Signal Levels up to 160Channels can be displayed simultaneously on the LCD
- PLL tuning system for precise frequency measurement and tuning
- Built-in Frequency Counter
- LED Backlight LCD (192x192 dots)
- All functions are menu selected.
- RS232C with software for PC & printer interface
- Built-in speaker

(Includes Antenna)**B&W Pinhole Bullet Camera w/ 1/3" CCD**

- Weather Resistant Housing
- Signal System: EIA
- Image Sensor: 1/3" CCD Bullet Hole
- Effective Pixels: 510 x 492
- Horizontal Resolution: 380TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-305CP**1-4: **\$49.00**5+: **\$46.00**

Details at Web Site

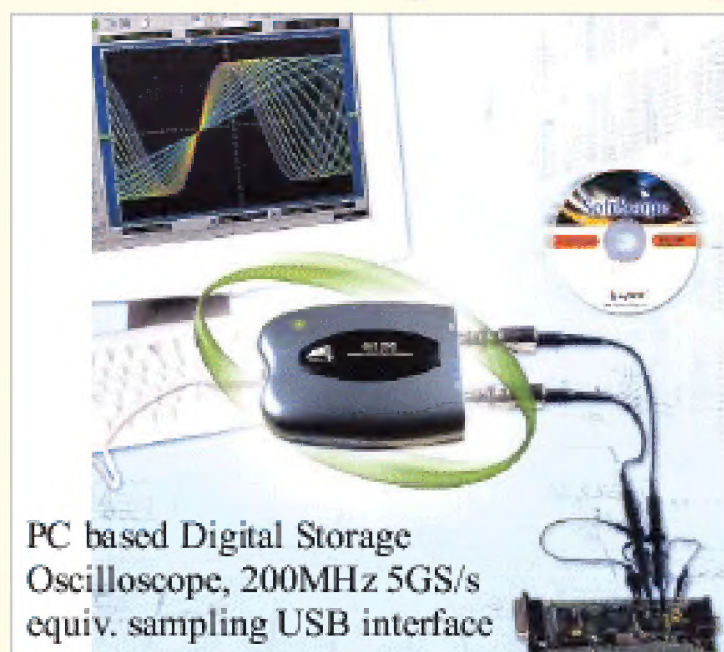
> Miniature Cameras (Board, Bullet, Mini's, B/W, Color)

**4 Channel Digital Video Recorder**

- Signal System: NTSC
- Operation System: Embedded RTOS
- Video Input: BNC x 4
- Video Output: BNC x 1 / VCR OUT
- Resolution: NTSC 720x480/ NTSC 640x240
- HD Capacity: Max. Capacity up to 250GB
- Backup: VCR
- Alarm In/Out: 4 in NO/NC, 1 Out No

Item #'s **VR-214 & VR-214-250G****Only \$289.00 & \$429.00****NEW!**

Details at Web Site > Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

Digital Storage Oscilloscope Module

Convert any PC with USB interface to a high performance Digital Storage Oscilloscope. This is a sophisticated PC based scope adaptor providing performance compatible to mid/high level stand alone products costing much more! Comes with two probes.

Details & Software Download at Web Site

> Test Equipment > Oscilloscopes/Outstanding Prices

Item# **200DSO** Only **\$899.00****LogicPort Logic Analyzer**

The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

- 34 Channels
- 500MHz Timing mode sample rate
- 200MHz State mode sample rate
- Real-time Sample Compression
- Multi-level trigger
- +6V to -6V Adjustable Threshold

Item# **LOGICPORT**

Details at Web Site > Test Equipment > Logic Analyzers

\$369.00!**Plug-In Switching Power Supplies**

These 15W switching power supplies are an inexpensive way to power devices with robust regulated power and low ripple noise. The low-profile design allow you insert them into a power strip without losing any of the other plugs. Designed with an energy efficient switching technology, the **Universal AC input works from 90-264VAC** with no minimum load required and a 100% burn-in test to ensure they will perform as stated right out of the box. They come with a 1.8 meter output cord and a 5.5 x 2.1mm female plug. UL and cUL approved.



Item#	Description
3A-161WU05	5 Volts / 2.6 Amps
3A-161WU06	6 Volts / 2.5 Amps
3A-161WU09	9 Volts / 1.70 Amps
3A-161WU12	12 Volts / 1.25 Amps
3A-161WU18	18 Volts / 0.84 Amps
3A-161WU24	24 Volts / 0.63 Amps

Each	10+	25+	100+
\$9.95	\$8.95	\$8.49	\$6.95

Details at Web Site > Test Equipment > Power Supplies

NEW!**SONY Super HAD CCD Color Weatherproof IR Cameras**

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 480TV lines
- Min. Illumination: 0Lux

Item# **VC-827D** 1-4: **\$149.00** 5+: **\$139.00****480 TV Lines Resolution****SONY Super HAD CCD B/W Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-317D** 1-4: **\$69.00** 5+: **\$65.00****SONY Super HAD CCD™ equipped camera's feature dramatically improved light sensitivity****SONY Super HAD CCD Color Camera**

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-805** 1-4: **\$69.00** 5+: **\$65.00**

Details at Web Site

> Miniature Cameras(Board,Bullet,Mini's, B/W, Color)

**SONY Super HAD CCD Color Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-819D**
1-4: **\$89.00** 5+: **\$79.00****SONY Super HAD CCD Mini B/W Board Camera**

- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV Lines
- Min. Illumination: .05Lux/F1.2

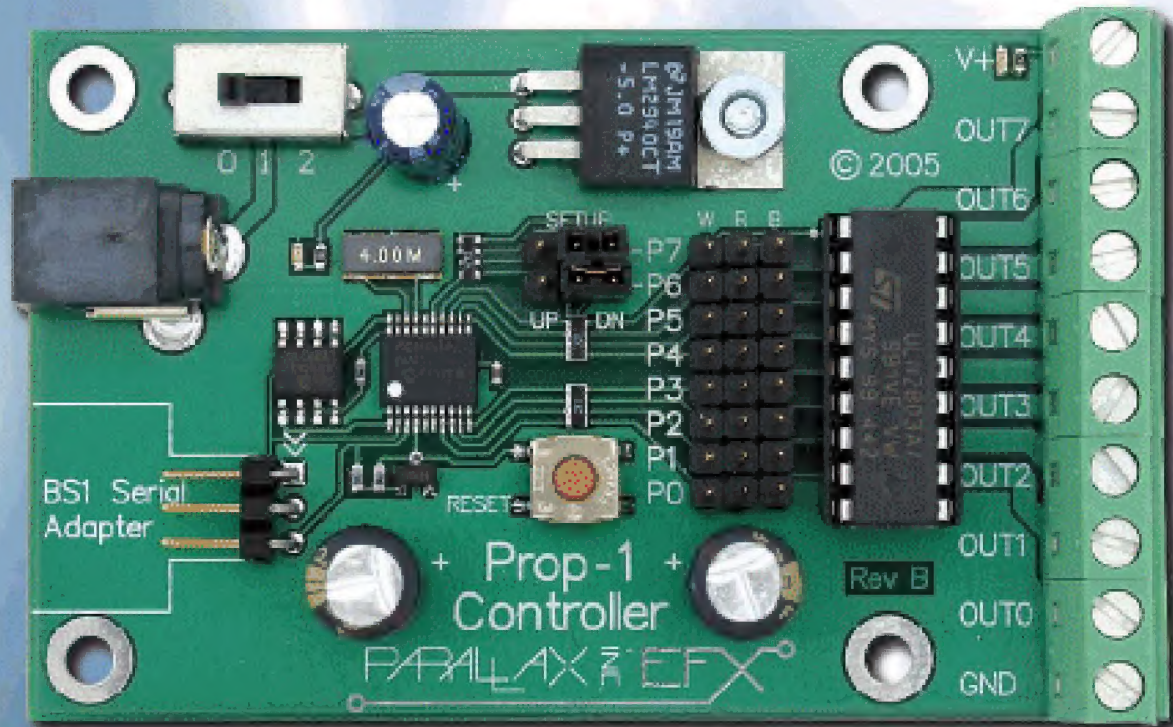
Item# **VC-103** 1-4: **\$33.00** 5+: **\$29.00**

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ www.CircuitSpecialists.com. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors, miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCB fabrication, educational D.I.Y. kits, cooling fans, heat shrink, cable ties & other wire handling items, hand tools for electronics, breadboards, trainers, programmers & much much more! **Some Deals you won't believe!**

Circuit Specialists, Inc. 220 S. Country Club Dr., Mesa, AZ 85210**800-528-1417 / 480-464-2485 / FAX: 480-464-5824**

Circle #35 on the Reader Service Card.

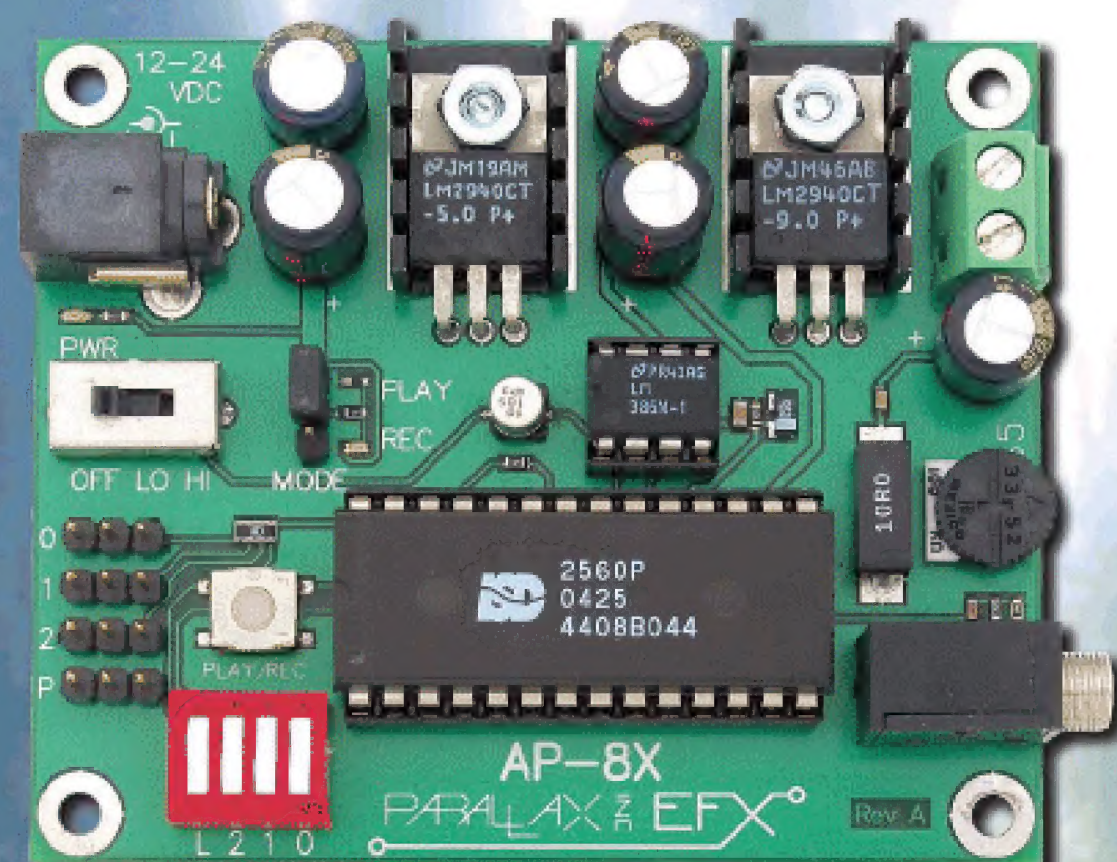
Parallax EFX™ can turn your digital control NIGHTMARES into *Sweet dreams* come true



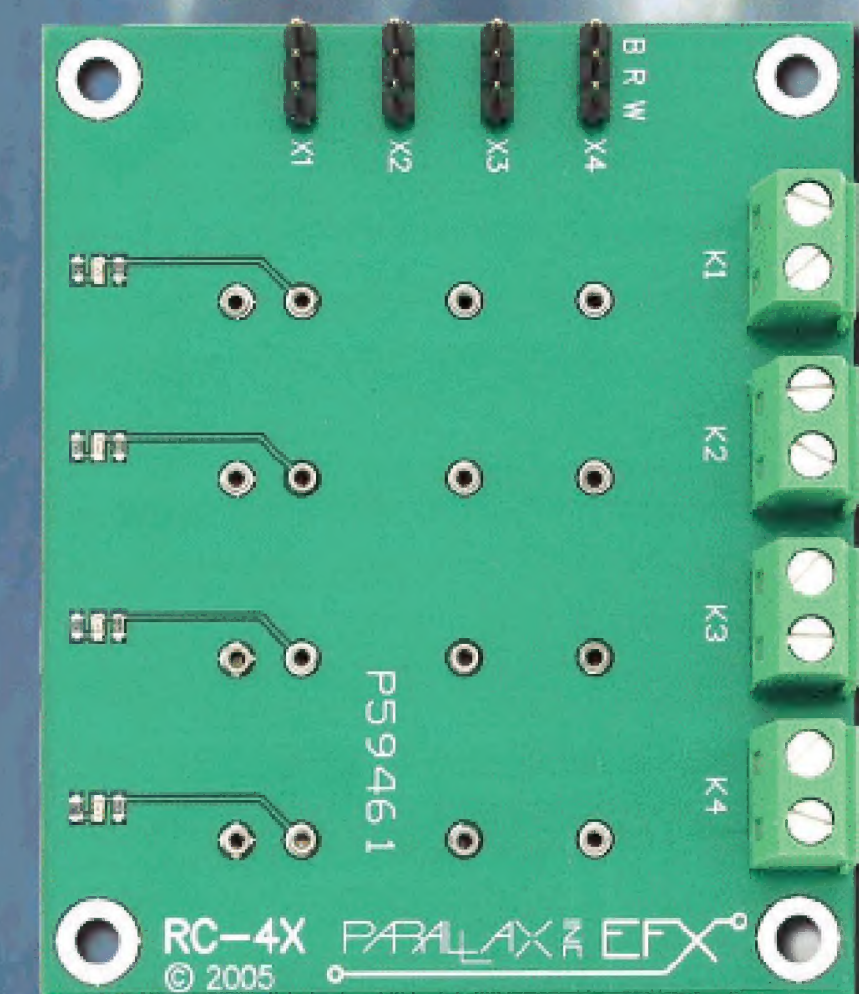
Want affordable and precise digital control?

Don't be afraid. With the easy-to-use Prop-1 Controller and the entire line of Parallax EFX products at your side, digital control is within your reach. Non-programmers will appreciate our super-simple BASIC language.

Prop-1 Controller (#31101 - \$34.95) - The Prop-1 Controller is a single board solution that is perfectly suited for many haunt and prop applications. Built from the BASIC Stamp® 1 microcontroller, the Prop-1 offers eight I/O pins and is powered by either 12 or 24 VDC. It can control TTL outputs (5VDC), hobby servos, 12-24 VDC solenoids, low voltage lamps, and small DC motors. A three-position power switch allows the use of one power supply, or two isolated power supplies.

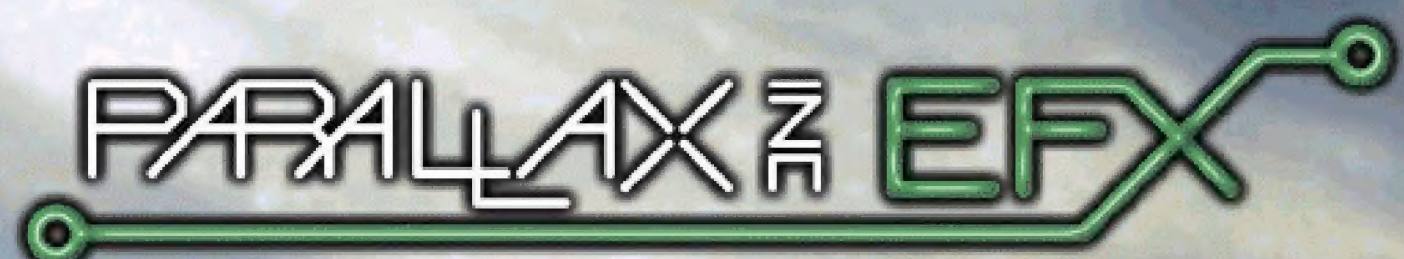


AP-8X Sound Board (#31308 - \$49.95) - The AP-8X audio player allows you to easily record and playback up to eight sounds totaling 60 seconds. These sounds may be recorded in any order and played back in any order. Playback can be controlled with a controller, or simple switches. Includes an on-board bi-level selectable amplifier and volume control, which changes volume from a loud gasp to a *blood-curdling scream!*



RC-4X Relay Board (#31204 - \$24.95) - Safely control 110-220 VAC loads with the popular Crydom D2W202 series of SSR. The RC-4X connects to the Prop-1 with three-pin cables to safely transmit low-voltage control signals to the SSRs. Small, bright LEDs indicate which loads are "hot."

Available individually or as package deals in September 2005. Order online at www.parallaxEFX.com or call our Sales Department toll-free at 888-512-1024 (Monday-Friday, 7am-5pm, PT).



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